CONESTOGA-ROVERS & ASSOCIATES

www.CRAworld.com

Corrective Action Plan for Reducing Concentrations Downgradient of the Source Containment System

G&H Landfill Site
Macomb County, Michigan

Prepared for: G&H PRP Group

Conestoga-Rovers & Associates
1880 Assumption Street, Unit 200
Windsor, Ontario N8Y 1C4

December 2013 • 051853 • Report No. 25

Partners in Sustainability

Table of Contents

List of Figures
(Following Text)

List of Tables
(Following Text)

List of Appendices
(Following Text)

List of Plans

Section 1.0 Introduction

Conestoga-Rovers & Associates (CRA) has prepared this Corrective Action Plan (CA Plan) for reducing the downgradient concentrations on behalf of the G&H Landfill PRP Group (Group), in response to the United States Environmental Protection Agency (U.S. EPA) letter received on November 26, 2013 (Letter) requesting Corrective Action Plans for addressing certain matters at the G&H Landfill Superfund Site as further discussed below.

The Letter questions the ability of the remedy to attain the groundwater cleanup standards within specified timeframes of groundwater extraction system operation and requires a Corrective Action Plan be submitted within 30 days consistent with the Scope of Work (SOW) attached to the Consent Decree entered into United States Vs. Browning-Ferris Industries, Inc., et al., Civil Action No. 92 CV 75460 OT for the Site.

The Corrective Action Plan is organized into the following sections:

Section 2.0 Background

The third Five-Year Review (FYR) was issued by the U.S. EPA on September 23, 2011. The FYR identified various compounds that exceeded the established maximum contaminant levels (MCLs) or cleanup standards derived under Michigan's former Act 307 in the downgradient aquifer plume. In particular, the FYR identified arsenic, cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride as exceeding their cleanup standards downgradient of the barrier wall. Data from the 2008 five-year monitoring event was assessed, and the FYR determined that fifteen additional compounds exceeded their established MCL value and/or Michigan's former Act 307, Type B criteria, and additional five compounds exceeded a lifetime cancer risk of 10^{-6} or a hazard index value of 1.0. Consistent with the requirements stated in the SOW, the FYR stated these parameters should be added to the list of groundwater cleanup standards for the Site. Furthermore, the FYR questioned the adequacy of the existing groundwater monitoring

network to determine the continued protectiveness of the Site. The FYR recommended an evaluation of the monitoring network and analytes be performed as a follow-up action.

The November 26, 2013 U.S. EPA Letter states that:

- Arsenic cleanup standards are being exceeded in the groundwater downgradient of the containment system, with predominantly either no trend, or an upward trend in contamination levels
- Benzene standards are being exceeded in the groundwater downgradient of the containment system, with predominantly either no trend, or an upward trend in contamination levels
- Cis-1,2-Dichloroethene cleanup standards are being exceeded in the groundwater downgradient of the containment system, with predominantly no trend in contamination levels
- Lead cleanup standards are being exceeded in the groundwater downgradient of the containment system, with predominantly either no trend, or an upward trend in contamination levels
- Vinyl chloride cleanup standards are being exceeded in the groundwater downgradient of the containment system, with predominantly no trend in contamination levels
- Barium was detected outside the containment system at levels above MCLs

The Letter does not identify the basis for the above summary, but, it is our understanding from discussions with the U.S. EPA that the basis was a draft report completed by S.S. Papadopolis & Associates, Inc. (SSPA) as a contractor for U.S. EPA in March 2012.

The following section presents CRA's review of the analytical data for the Site for the constituents discussed in U.S. EPA's Letter.

2.1 Data Analysis

It should be noted that CRA was provided a draft copy of the SSPA report figures and tables on January 25, 2012 by the U.S. EPA. A final version of this report was not provided to CRA or the Group at that time, nor did the Group have an opportunity to comment on the report. CRA subsequently received a draft copy of the March 2012 report on December 23, 2013 from Mr. Jeffrey Cahn of the U.S. EPA. Upon review of the draft figures and tables, it was noted that the data set used in the SSPA report included samples collected between 2007 and 2010. The data evaluation presented in the report was performed using protocol analysis module (PAM) software, which consists of comparing data to an Upper Confidence Level (UCL)/Standards and trend analysis. Given that only data from 2007 to 2010 was utilized, the Group feels that the analysis of the data in the SSPA report and as summarized in the letter presents a misleading view and evaluation regarding the existing conditions at the Site. In preparing this Plan, the Group has completed a review of analytical data from 2000 to 2013 for the constituents identified in the Letter, which is described below.

CRA completed an updated data evaluation, using Mann-Kendall trend test to determine if statistically significant upward or downward trends exist in analyte concentrations over time. The results are presented in Table 1. The Mann-Kendall test, which is commonly applied to environmental monitoring data (Helsel and Hirsch [1992]; U.S. EPA [2009]) is a non-parametric (rank-based) method that evaluates a set of data for a monotonic (unidirectional) trend result. The procedure makes no assumptions regarding the shape of the trend (e.g., linear, log linear), except that the trend is in a single direction (i.e., either consistently upward or downward).

In implementing the Mann-Kendall trend test, a significance level of 0.05 (i.e., 95-percent confidence) was used for data sets with more than four samples. Performing the trend tests at a confidence level of 0.05 results in a false positive rate (concluding a significant trend when none is present) of 5%. However, for smaller data sets containing four results, a significance level of 0.10 (i.e., 90-percent confidence) was applied, since it is not mathematically possible to achieve 0.05 significance for a two-sided test (i.e., testing for either increasing or decreasing trends) with only four points (see Table B8 of Helsel and Hirsch, 1992). No test was performed if three or fewer data points were available.

For the purposes of performing the Mann-Kendall trend test, non-detects were considered to be tied (i.e., equal) values with concentrations lower than the detected concentrations. Any field duplicate results were averaged prior to completing the trend analyses. If one field duplicate was a detected value and the other a non-detect, the detected result was conservatively retained to represent a maximum estimate of the analyte concentration. Any individual observations with ambiguous rankings for the Mann-Kendall test (i.e. either a detected value – typically "J-qualified" – below other detection limits; or an elevated detection limit above other detected values) were dealt with on a case-by-case basis to obtain the most appropriate trend test.

The Mann-Kendall trend test was applied for data sets containing up to 50 percent non-detects. At very high non-detect rates (above 50 percent), the Mann-Kendall test loses sensitivity and is of limited utility in assessing trends. Thus, any data sets in which parameters were non-detect in more than 50 percent of samples were excluded from statistical evaluation.

Arsenic, lead, benzene, cis-1,2-DCE and vinyl chloride groundwater data were generated from samples collected at 65 wells at the Site. Two time periods were considered when testing for temporal trends:

1. All data collected since 2000 to present
2. The last 5 years of data (2009-2013)

An analysis of the data for each of the parameters presented in the Letter is provided in the following sections.

2.1.1 Arsenic

The FYR stated that arsenic cleanup standards are being exceeded in groundwater downgradient of the containment system. The Letter states that predominately no trend or an upward trend is observed in arsenic contaminant levels at the Site.

CRA agrees that the arsenic cleanup standard continues to be exceeded in groundwater downgradient of the containment system, as presented on Plan 1. Based on CRAs review of data from 2000 to 2013, there does appear to be increasing upward or downward arsenic trends at various locations including several upgradient locations, as presented on Table 1. However, when more current data is analyzed, only three locations exhibit an increasing trend (GH-02B, GH-16A, and GH-34B). Figure 1 presents trend analysis plots for arsenic at various upgradient and downgradient locations at the Site.

The Consent Decree cleanup standard for arsenic is 0.02 micrograms per liter (µg/L), and the MCL for arsenic is 10 µg/L. Section II E. 1, Table 1 of the SOW indicates that a background arsenic value may be used if higher than the cleanup standard. CRA completed a preliminary background arsenic analysis and derived a value of 25.3 µg/L when data from upgradient monitoring wells GH-14A/B, GH-15A/B, GH-16A/B, GH-17A/B, GH-47A/B, BW-1A/B, BW-2A/B and BW-3A/B is included in the calculations. Appendix A provides a summary of the calculated arsenic background value. This value is significantly higher than the current Site cleanup standard of 0.02 µg/L for arsenic. The current cleanup standard is extremely low as it is 500 times lower than the MCL, and is a risk based value based on now out of date risk applications. The typical detection limit for arsenic is 20 µg/L, therefore the vast majority of detections exceed the cleanup standard. Water quality maps for Michigan (DEQ, 2013) indicate that background levels in Macomb County in the vicinity of the Site ranged from 20 to above 50 µg/L. Although concentrations of arsenic in many wells have been reduced from their original levels, concentrations above 50 µg/L remain at various locations downgradient of the containment system.

2.1.2 Benzene

The Letter states that benzene concentrations are exceeding the standards in groundwater downgradient of the containment system with predominantly no trend or an upward trend in contamination levels.

The Consent Decree cleanup standard for benzene is 1.0 µg/L, and the MCL for benzene is 5.0 µg/L. Based on CRAs review of the data from 2000 to 2013, 22 of 71 wells have exceeded the benzene cleanup standard at least once; however only eight wells (GH-50, GH-51, GH-53, GH-66, GH-67, GH-68, GH-69 and GW-10) currently exceed the cleanup standard, as presented on Plan 1. All of these eight wells are located in areas where implementation of the corrective action outlined in the December 16, 2013 Corrective Action Plan for Improving Collection System Performance is expected to have a positive impact on the groundwater quality. Of these eight locations, seven are located in the southwest corner of the Phase II Landfill and only two wells exhibit a slightly increasing trend (GH-50 and GH-51), as

presented in Table 1. When only recent data is used (2009 to 2013), no trend is present in these wells, however, a very slight increasing trend is observed for GH-66 and GH-68. It should be noted that none of the wells exceed the MCL.

The majority of the remaining wells that exceeded the cleanup standards for benzene prior to implementation of the Remedial Action now have concentrations that are below criteria, most of which are non-detect. Figure 2 presents trend analysis plots for benzene at the locations with current exceedances and selection locations that exhibited historical exceedances of the benzene cleanup standard.

2.1.3 cis-1,2-Dichlorethylene

The FYR states that cis-1,2-dichloroethylene (cis-1,2-DCE) concentrations are exceeding the standards in groundwater at one location downgradient of the containment system. The Letter states that cis-1,2-DCE exhibits predominantly no trend in contamination levels at the Site.

The Consent Decree cleanup standard for cis-1,2-DCE is 1.0 µg/L, and the MCL for cis-1,2-DCE is 70 µg/L. Based on CRAs review of the data from 2000 to 2013, nine of 71 locations have exceeded the cis-1,2-DCE cleanup standard at least once, however only one location continues to exceed the cleanup standard (GH-43B), as presented on Plan 1. This location exhibits a slightly increasing trend (GH-43B), which is located downgradient of the containment system, as presented in Table 1. Figure 3 presents trend analysis plots for cis-1,2-DCE at GH-43B and other select locations that exhibited historical exceedances of the cis-1,2-DCE cleanup standard.

2.1.4 Vinyl Chloride

The FYR states that vinyl chloride concentrations are exceeding the standards in groundwater downgradient of the containment system at one location. The Letter states that predominantly no trend in contamination levels is observed for vinyl chloride at the Site.

The Consent Decree cleanup standard for vinyl chloride is 1.0 µg/L, and the MCL for vinyl chloride is 2.0 µg/L. Based on CRAs review of the data from 2000 to 2013, seven of 71 locations have exceeded the vinyl chloride cleanup standard at least once, however only one location continues to exceed the standard (GH-43B), at which a strong decreasing trend is observed, as presented on Plan 1 and Figure 4. Concentrations of vinyl chloride at GH-43B have been reduced by approximately five times since implementation of the Remedial Action from 25 µg/L in July 2002 to 4.1 µg/L in June 2013. The vinyl chloride concentrations at GH-43B have exhibited a clear and strong decreasing trend over the course of operations at the Site, as presented in Table 1, and are expected to be below criteria within the coming years. Figure 4 presents a trend analysis plot for vinyl chloride at GH-43B.

2.1.5 Lead

Although the FYR did not identify lead as a concern at the Site, the Letter states that lead concentrations are exceeding the standards in groundwater downgradient of the containment system with predominantly no trend or an upward trend in contamination levels.

The Consent Decree cleanup standard for lead is 5 µg/L, and the MCL for lead is 15 µg/L. Based on CRAs review of the data from 2000 to 2013, thirteen of 71 locations have exceeded the lead cleanup standard at least once, however only five locations (GH-01B, GH-02A, GH-02B, GH-20B and GH-25A) continue to exceed the standard, as presented on Plan 1. An increasing trend is observed at one location (GH-20B), however, when more current data is used (2009 to 2013), no trend is identified in this well, as presented in Table 1. Figure 5 presents trend analysis plots for GH-20B and one other location that exhibited exceedances of the lead standard.

2.1.6 Barium

Although the FYR did not identify barium as a concern at the Site, the Letter states that barium was detected outside the containment system at levels above MCLs. However, CRA has not identified any monitoring locations where barium exceeds the MCL of 2 mg/L.

2.1.7 Site Summary

The leachate containment system began operating approximately 14 years ago, and has been successful in reducing concentrations of most parameters at the Site as indicated by the evaluation discussed above. With the exception of a few isolated areas and sampling events, the concentrations of volatile organic compound (VOC) parameters, including benzene, cis-1,2-DCE and vinyl chloride, on the cleanup standard list are below their associated cleanup standards. The isolated areas that still display concentrations that are above the cleanup standard are generally exhibiting a decreasing trend, or have no trends observed during the recent period.

Arsenic concentrations at the Site appear to be overall stable, with the exception of three locations that exhibit an increasing trend in the recent past, one of which is located upgradient to the Site. The stable conditions and increasing trends in some areas may be due to natural/background variations in groundwater quality.

Only one historically increasing trend for lead was observed downgradient of the barrier wall, where recent data indicate no trend.

Concentrations of barium upgradient and downgradient at the Site remain well below the MCL for barium.

Overall, CRA's assessment of the groundwater conditions downgradient of the source containment system identified exceedances of the cleanup standards for a select few parameters in isolated areas of the Site. The statements presented in the U.S. EPA Letter do not accurately reflect the current conditions at the Site. Other than for arsenic and the area located in the southwest corner of the Phase II Landfill, these exceedances are isolated to individual wells. The Group believes that measures being pursued to improve the performance of the containment system as well as the extraction system, as outlined in the Corrective Action Plan for Improving Collection System Performance, submitted to the U.S. EPA and MDEQ on December 16, 2013, will result in a further reduction of the concentrations southwest of the Phase II Landfill.

The following sections present the proposed measures for the Corrective Action Plan.

Section 3.0 Task 1 - Corrective Action Plan

3.1 Objectives

As presented in Section 2.1, the Site remedy has been successful in reducing the concentrations of the various constituents identified in the Letter at the Site. However, some isolated areas continue to have concentrations of various constituents above the cleanup standards downgradient of the containment system, as listed below:

- Downgradient of Barrier Wall - arsenic exceedances are present throughout the Site, including several background locations, due to the extremely low standard and natural conditions; however, concentrations downgradient of the containment system appear to be higher than upgradient locations, as presented on Plan 1. Additionally, lead concentrations remain above the cleanup standard at a few isolated locations downgradient of the barrier, as presented on Plan 1.
- Southwest Corner of Phase II Landfill – concentrations of benzene remain above the cleanup standard in this area, as presented on Plan 1.
- GH-43B – concentrations of cis-1,2-DCE and vinyl chloride remain above the cleanup standard at this isolated location, as presented on Plan 1.

The corrective action will focus on continued monitoring and assessment of the chemical concentrations following implementation of the corrective action measures presented in the Corrective Action Plan for Improving Collection System Performance. The following activities are proposed as part of the corrective actions for reducing the concentrations at the Site:

- Continued monitoring of the Site, as per the Operation and Maintenance Plan (OMP)
- Evaluation of current groundwater monitoring plan including existing monitoring well network and parameter list
- Finalize background determination for arsenic
- Assessment of chemical concentrations following the 2018 five-year monitoring event and provide recommendations for further actions, if necessary

The proposed corrective actions are further discussed in Section 3.2.1.

3.2 Scope of Work

3.2.1 Continued Site Monitoring

The OMP outlines a monitoring schedule for the Site, which includes semi-annual and annual groundwater monitoring at a select list of monitoring wells, semi-annual landfill gas monitoring, annual surface water monitoring, and quarterly water elevation monitoring. These monitoring events will continue to be completed during and following the implementation of the corrective measures outlined in the Corrective Action Plan for Improving Collection System Performance, to provide up-to-date analytical data for the Site. The monitoring events conducted following completion of the corrective measures outlined in the Corrective Action Plan for Improving Collection System Performance will provide information regarding the effectiveness of the corrective measures in reducing the concentrations at the Site, particularly in the areas southwest of the Phase II Landfill. The Mann Kendall trend analysis will be updated annually to observe the effects of the corrective measures.

Continued monitoring will be sufficient for identifying any significant changes to the groundwater conditions at the Site that would require the implementation of various corrective measures to address identified concerns.

3.2.2 Evaluation of Groundwater Monitoring Program

The OMP outlines a monitoring well network for the Site, and specifies the parameters to be monitored, which consist of a Site-specific list of metals and VOCs. Pursuant to Section II G5 of the SOW, every five years, a more comprehensive list of parameters are monitored at the Site, which consist of the target compound list (TCL) VOCs, TCL semi-volatile organic compounds (SVOCs), TCL polychlorinated biphenyls (PCBs), TCL Pesticides, target analyte list (TAL) metals, alkalinity, sulfate, total organic compounds (TOC), total cyanide and hardness. The last five-year sampling event was completed in June 2013. CRA is currently completing a report presenting the results of the 2013 five-year monitoring event data which will be reported to U.S. EPA in January 2014.

CRA will also evaluate the current groundwater monitoring program to assess revisions to the monitoring well network and current parameter list. The evaluation will focus on optimization of the monitoring well network and determine where additional monitoring wells may be required to confirm existing conditions and areas where further monitoring can be reduced or eliminated. The evaluation will also include an assessment of the integrity of the monitoring wells within the current monitoring well network.

The current parameter list for the groundwater monitoring program will be evaluated to determine if additional parameters should be added and whether any existing parameters can be deleted. The evaluation of the parameter list will consider the results of the current five-year monitoring event from June 2013 based on CRA's evaluation of the analytical results.

Proposed revisions to the monitoring program will be developed in coordination with U.S. EPA and MDEQ following the evaluation.

3.2.3 Arsenic Background Determination

As discussed in Section 2.1.1, CRA completed a preliminary background arsenic analysis based on various upgradient monitoring wells. Based on the preliminary analysis, a background value of 25.3 µg/L was calculated as presented in Appendix A. The SOW attached to the Consent Decree states in Table I that naturally occurring (background) arsenic levels found at the Site may be higher than the Cleanup Standard. In that event, background levels will become the Cleanup Standard.

CRA will evaluate the availability of additional data to be utilized in developing the background concentration for arsenic. While it appears that concentrations of arsenic downgradient of the containment system exceed the background concentration determined by CRA, formalization of a background concentration as the Site cleanup standard will create a new benchmark for evaluating the performance of the remedy and to determine an expected time frame for achieving criteria.

3.2.4 Re-Evaluation of Concentrations Downgradient of the Source Containment System

Based on CRA's evaluation of the current groundwater conditions at the Site, physical corrective measures, beyond those presented in the Corrective Action Plan for Improving Collection System Performance, do not appear to be warranted at this time. CRA proposes that a detailed review of the groundwater conditions downgradient of the source containment system be completed following the 2018 five-year monitoring event completed pursuant to Section II G5 of the SOW.

This is a reasonable time frame to allow the collection of additional data under the revised monitoring program as proposed in Section 3.2.2 and also provides a reasonable time frame for improvements from any corrective measures completed pursuant to the Correction Action Plan for Improving Collection System Performance to be realized.

As discussed in Section 3.2.1, continued monitoring under the OMP will identify any short term issues that occur at the Site that would require the implementation of a specific corrective measure.

Section 4.0 Task 2 – Corrective Action Design

To the extent that significant remedial measures become necessary to address issues downgradient of the source containment system, a detailed design including drawings and specifications will be prepared. The implementation of the design for significant remedial measures will be completed as follows:

4.1 Preliminary Design

Upon U.S. EPA approval of the selected corrective measures, a preliminary design report will be developed and submitted to the U.S. EPA for review and approval. The preliminary design report will outline the preliminary design, the conceptual layout and design basis for the selected corrective measures.

4.2 Pre-Final (95%) Design

A pre-final design report reflecting the 95 percent completion stage will be submitted for review and approval by the U.S. EPA. The pre-final design report will have addressed all comments generated from review of the preliminary design report and will include design drawings of the selected corrective measure.

4.3 Final Design

A final design report containing design plans and specifications at 100 percent completion will be submitted to the U.S. EPA for review and approval. The final design report will have addressed all comments generated from review of the pre-final design report.

Section 5.0 Task 3 – Corrective Action Construction

Upon approval of the Final Design, the Group will issue the drawings and specifications to selected construction firms to bid on the construction of the corrective measures. Upon selection of a suitable construction firm, the final remedy will be constructed and operated in accordance with the approved plan. A construction completion report along with a revised OMP will be prepared and submitted to the U.S. EPA upon completion of the construction.

Section 6.0 Schedule

Following U.S. EPA approval of this CA Plan, which is anticipated to be approved by January 20, 2014; the Arsenic Background Determination will commence, to be completed by February 14, 2014. The Evaluation of the Groundwater Monitoring Program will occur simultaneously, and an initial draft of the Group's proposed revisions to the monitoring program will be completed by March 7, 2014. The Site will continue to be monitored as per the OMP, with the incorporation of any approved changes from the monitoring program evaluation, for the calendar years 2014, 2015, 2016, 2017, 2018, etc. Following the next five-year sampling event, which is scheduled to occur in June 2018, a Re-Evaluation of Concentrations Downgradient of the Source Containment System will be completed. This supplemental evaluation will identify any additional corrective actions required and will determine the need for Corrective Action Design and Construction.

The schedule will be updated and revised during implementation of the corrective action activities as additional information and results of the evaluations become available. The Group will implement the corrective action activities presented above immediately upon approval by U.S. EPA and will make every effort to expedite completion of the schedule where possible.

Section 7.0 Summary

CRA has prepared this Corrective Action Plan in response to the U.S. EPA Letter received on November 26, 2013 regarding *Corrective Action Plans for Addressing Deficiencies and Concerns at the G&H Landfill Superfund Site*.

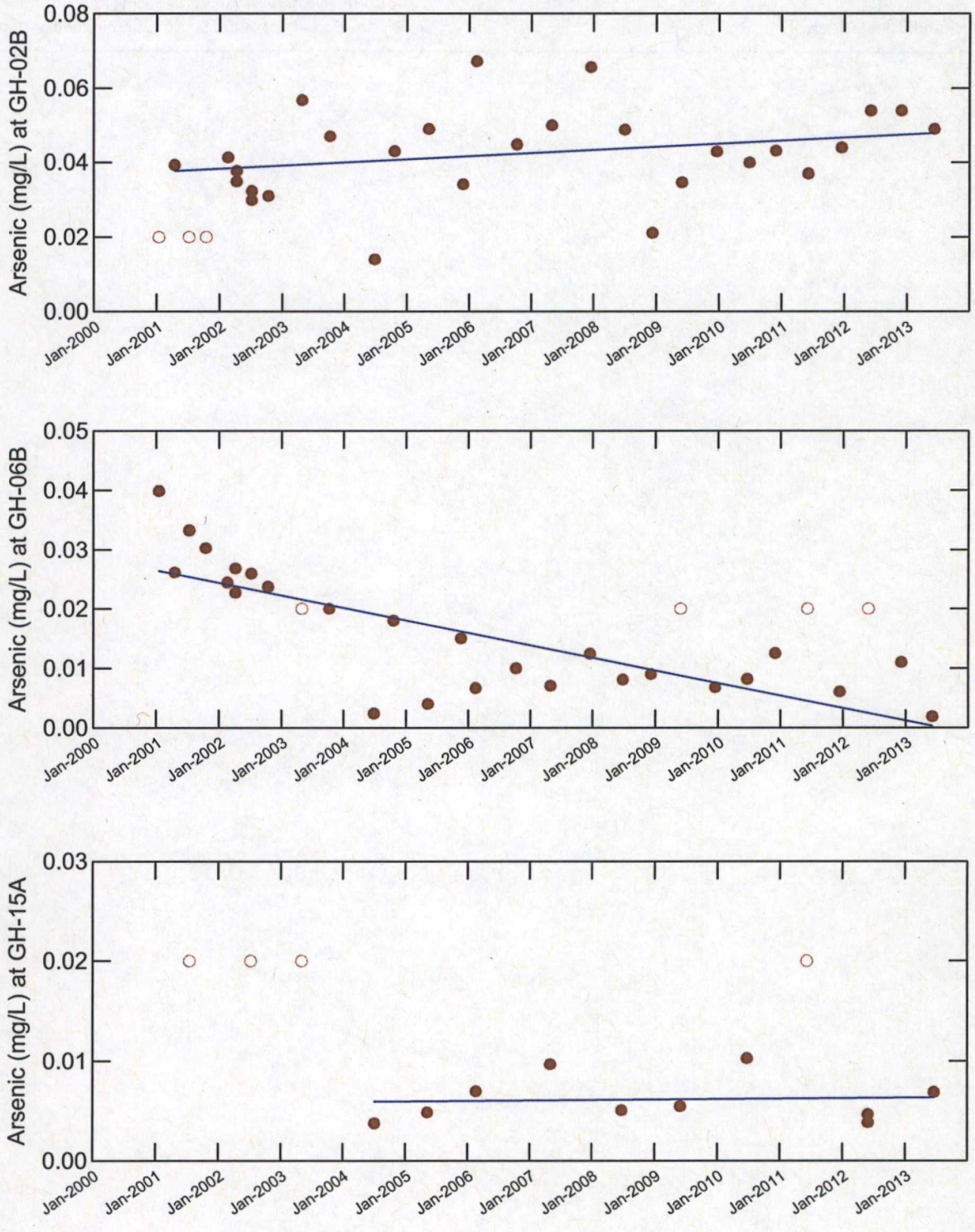
The proposed Corrective Action activities presented in this Plan will be implemented according to the Schedule as outlined in Section 7.0 upon U.S. EPA approval of this Plan.

Section 8.0 References

USEPA, [2009]. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance*. Office of Resource Conservation and Recovery, Program Implementation and Information Division, United States Environmental Protection Agency Washington DC. EPA 530-R-09-007.

Helsel, Dennis R., and Hirsch, Robert M. [1992]. *Statistical Methods in Water Resources*. Elsevier, ISBN 0-444-81463-9, Amsterdam, 522 p.

Figures



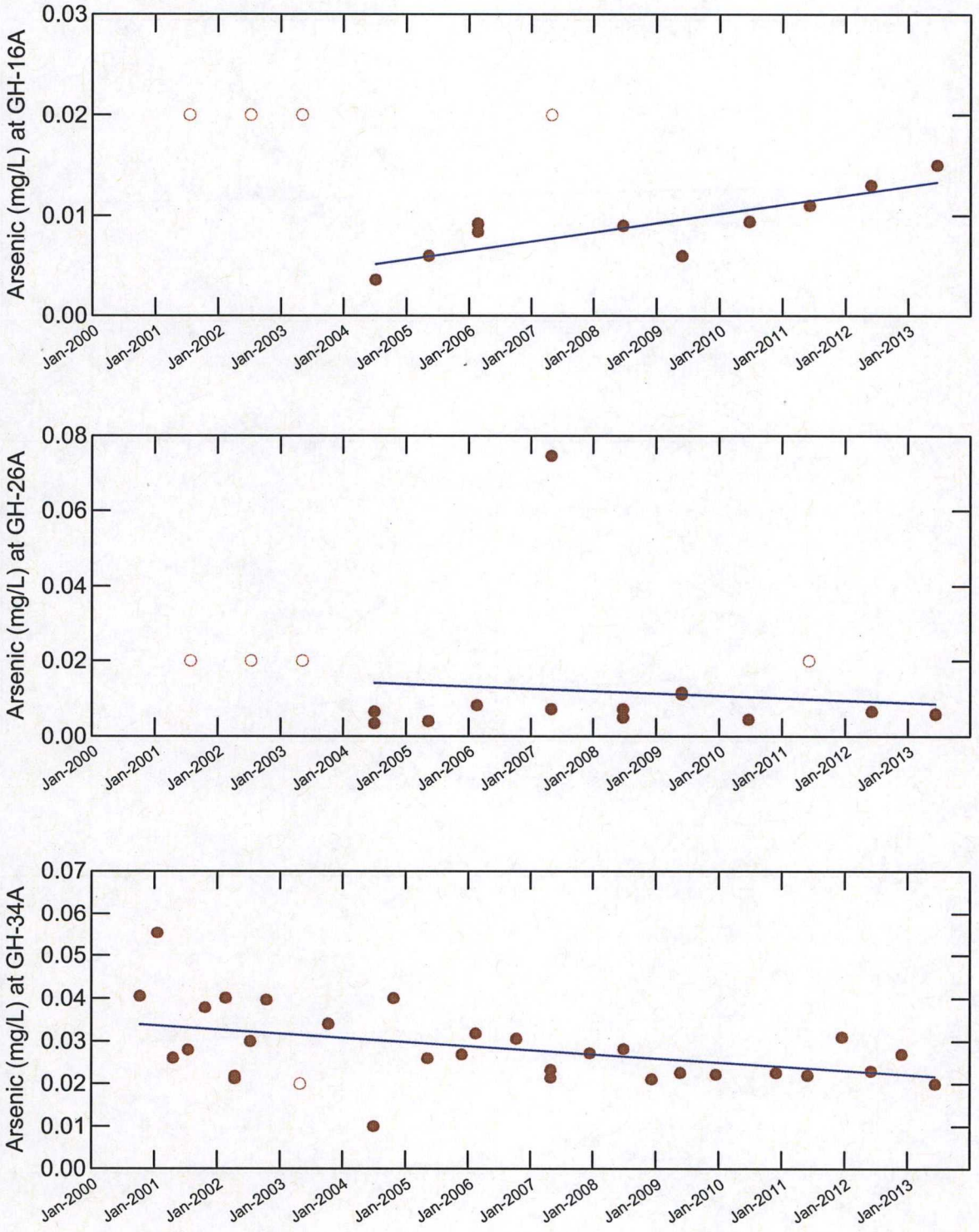
Notes:

- Detected result
- Non-detect result
- Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 1
Arsenic Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 18/2013

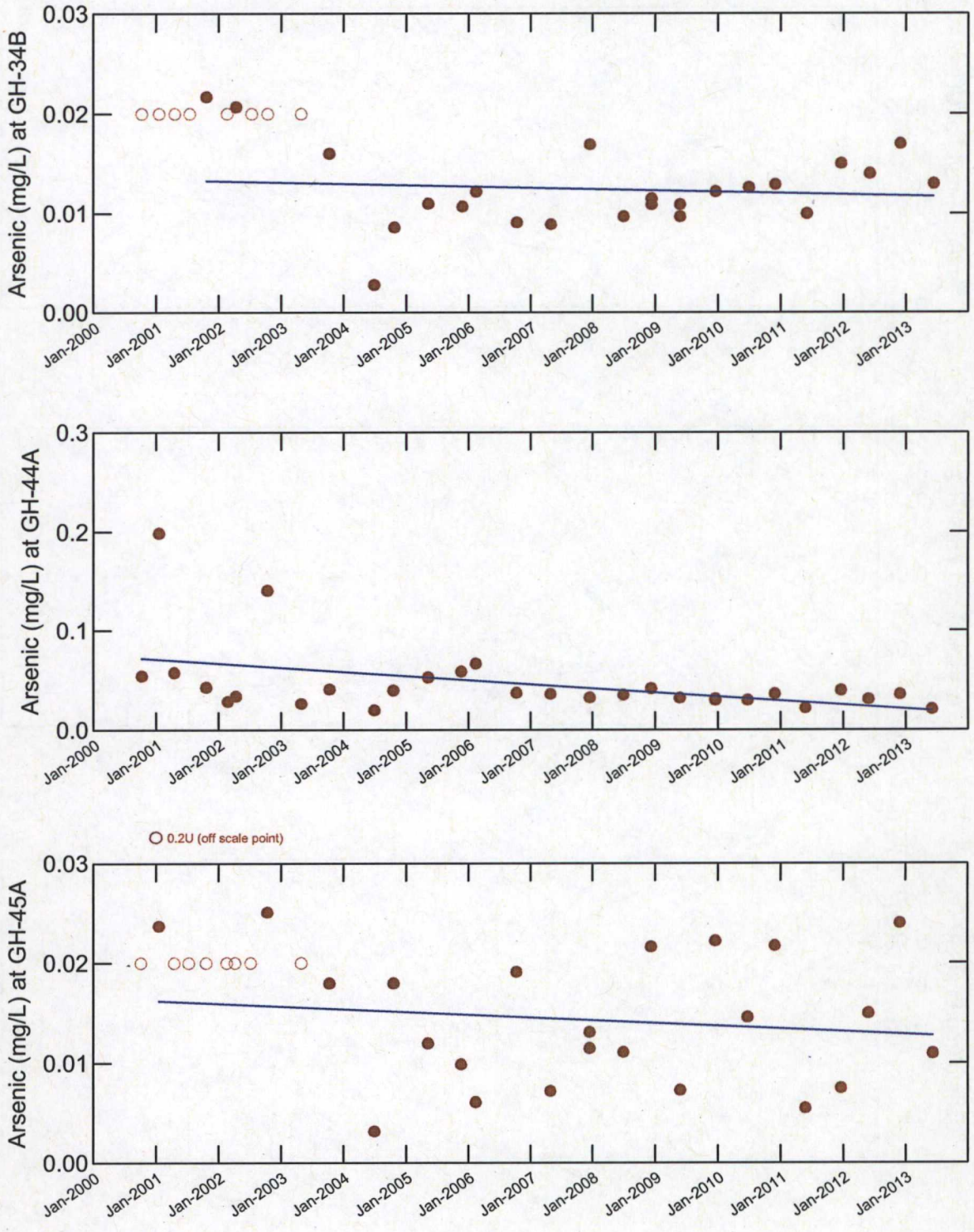


Notes:

- Detected result
- Non-detect result
- Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 1
Arsenic Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan



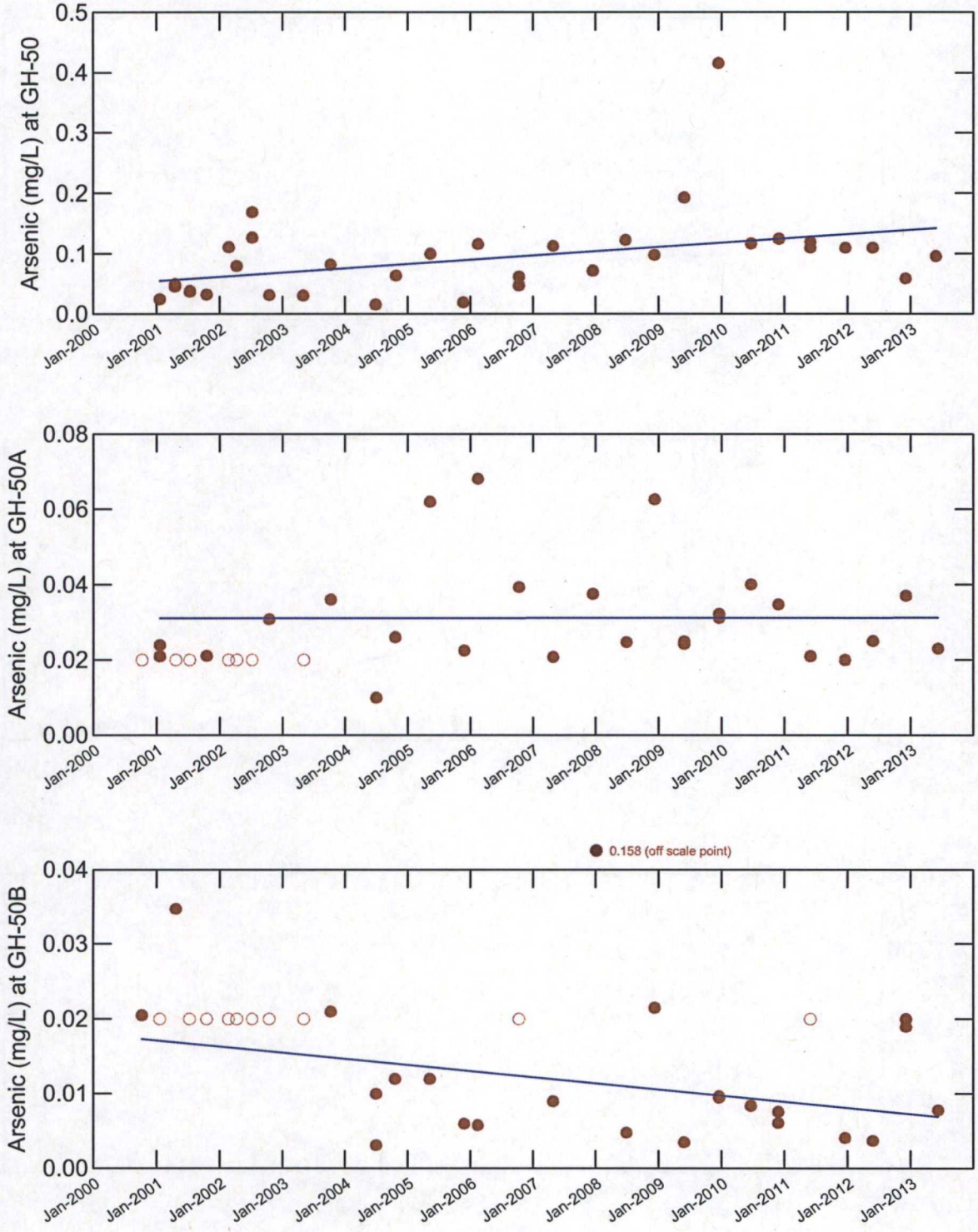
Notes:

- Detected result
- Non-detect result
- Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 1
Arsenic Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 18/2013

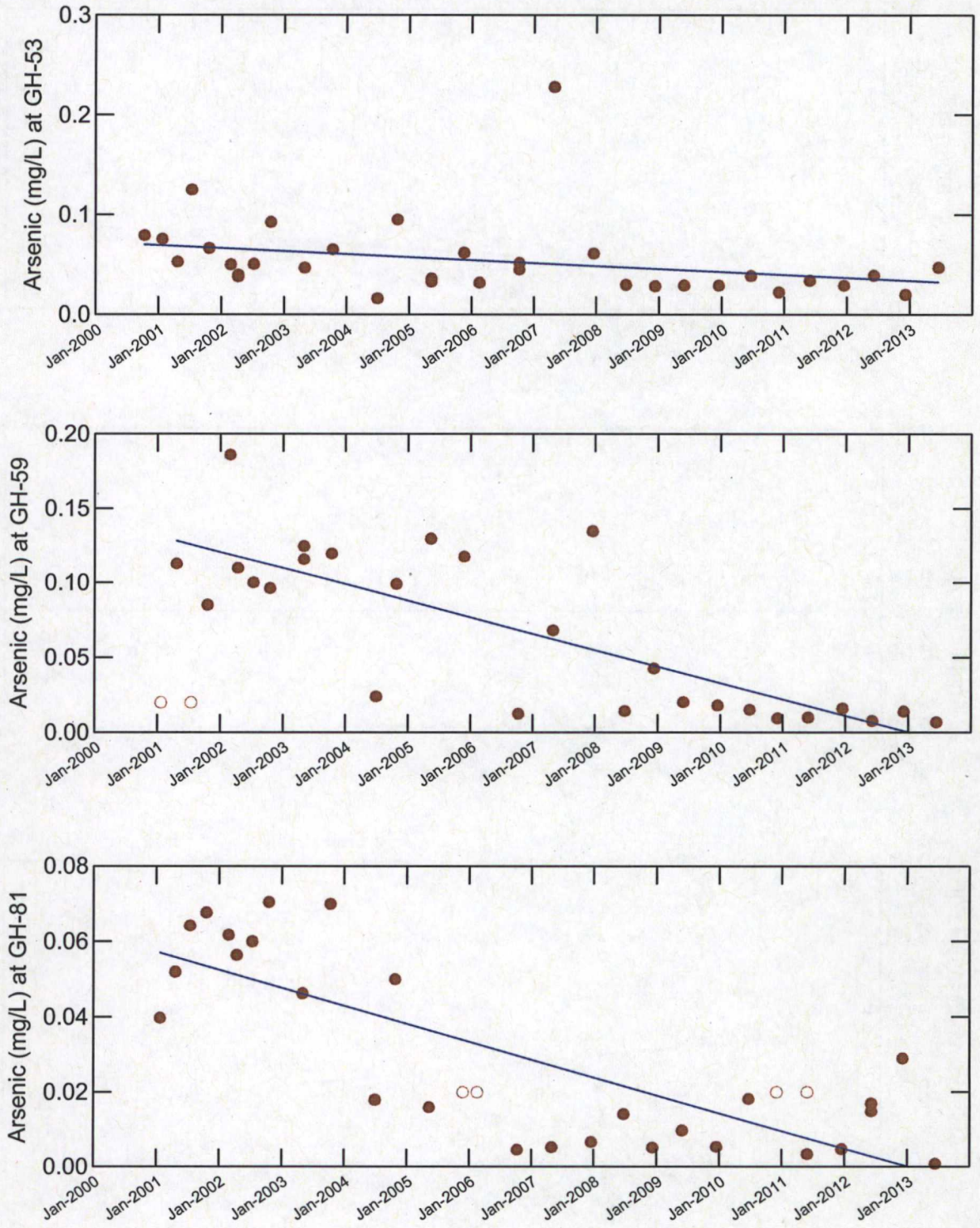


Notes:

- Detected result
- Non-detect result
- Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 1
Arsenic Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan



Notes:

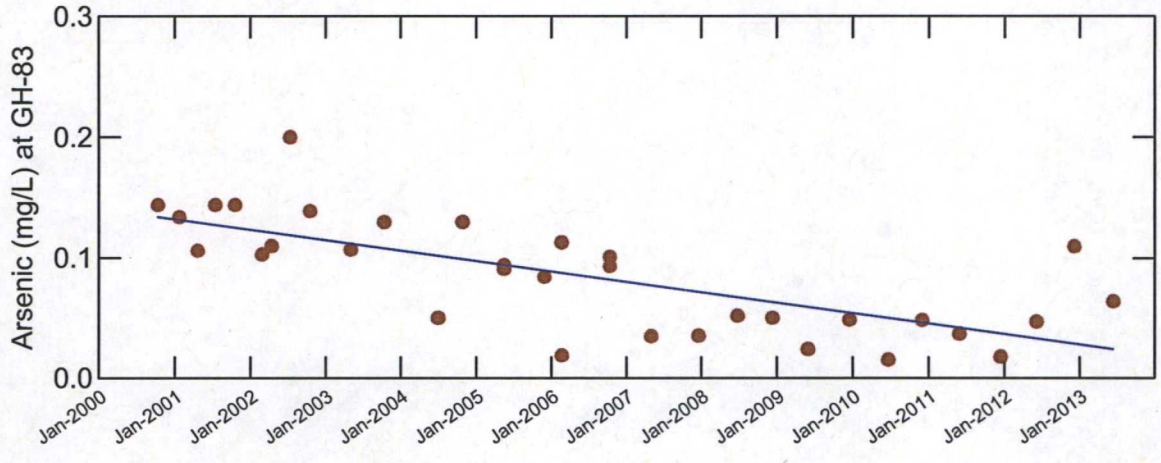
- Detected result
- Non-detect result

Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 1
Arsenic Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 18/2013



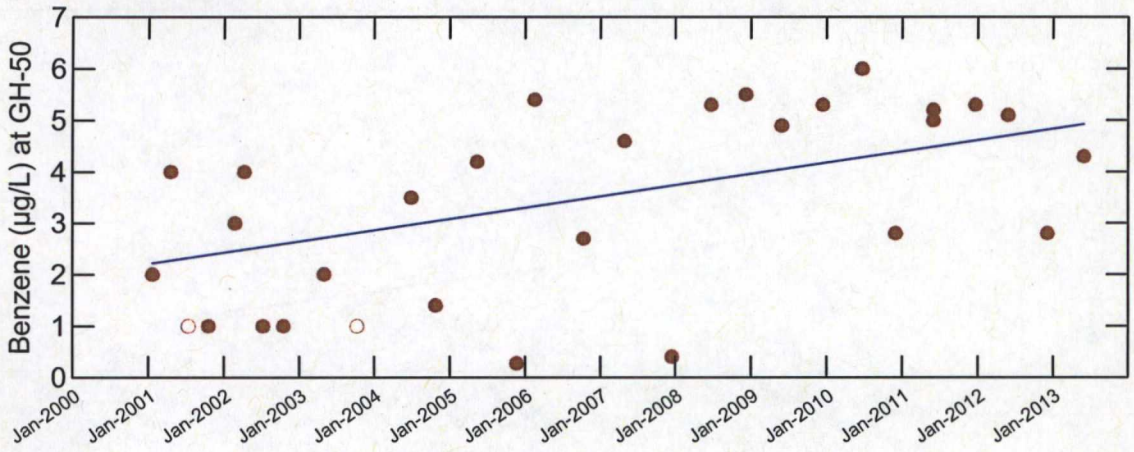
Notes:

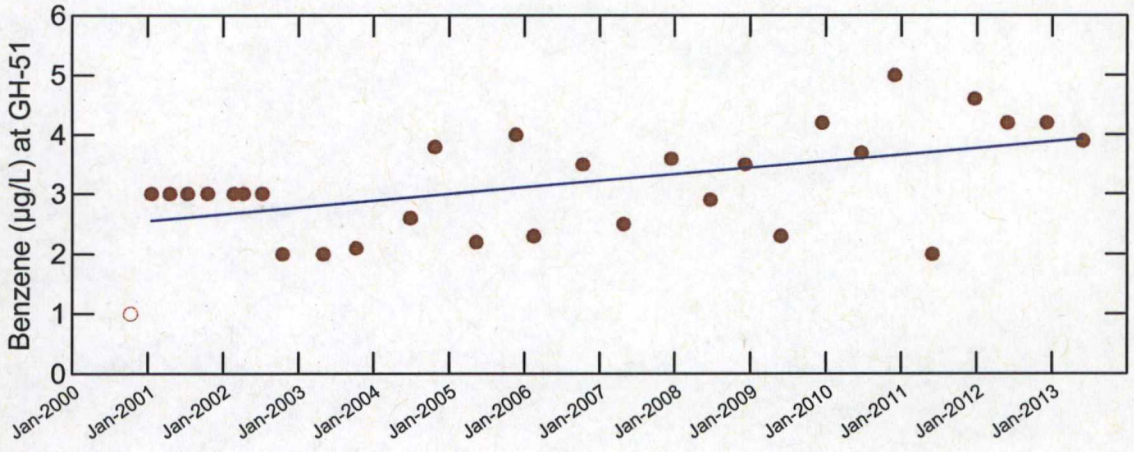
- Detected result
- Non-detect result
- Line of Best Fit (linear regression)

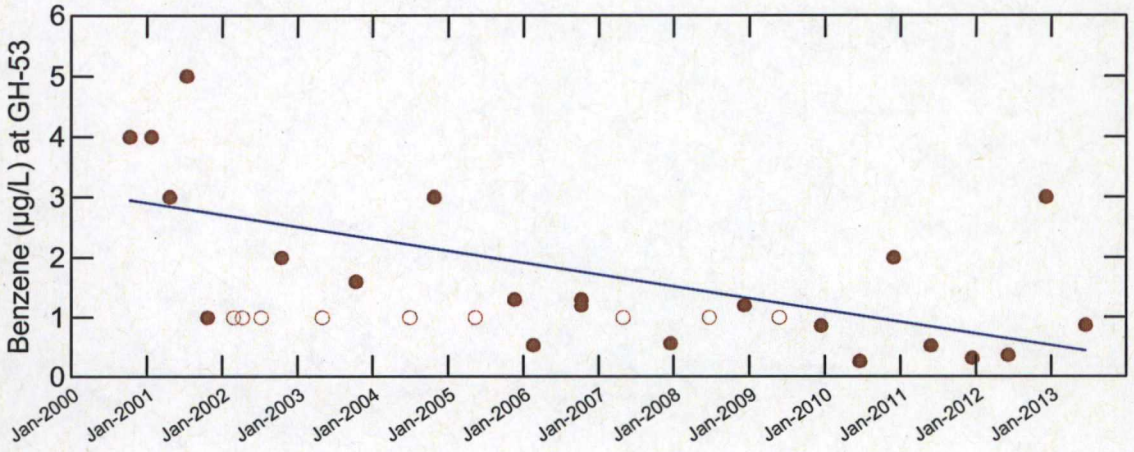
Line of Best Fit was calculated using detected values

figure 1
Arsenic Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 18/2013







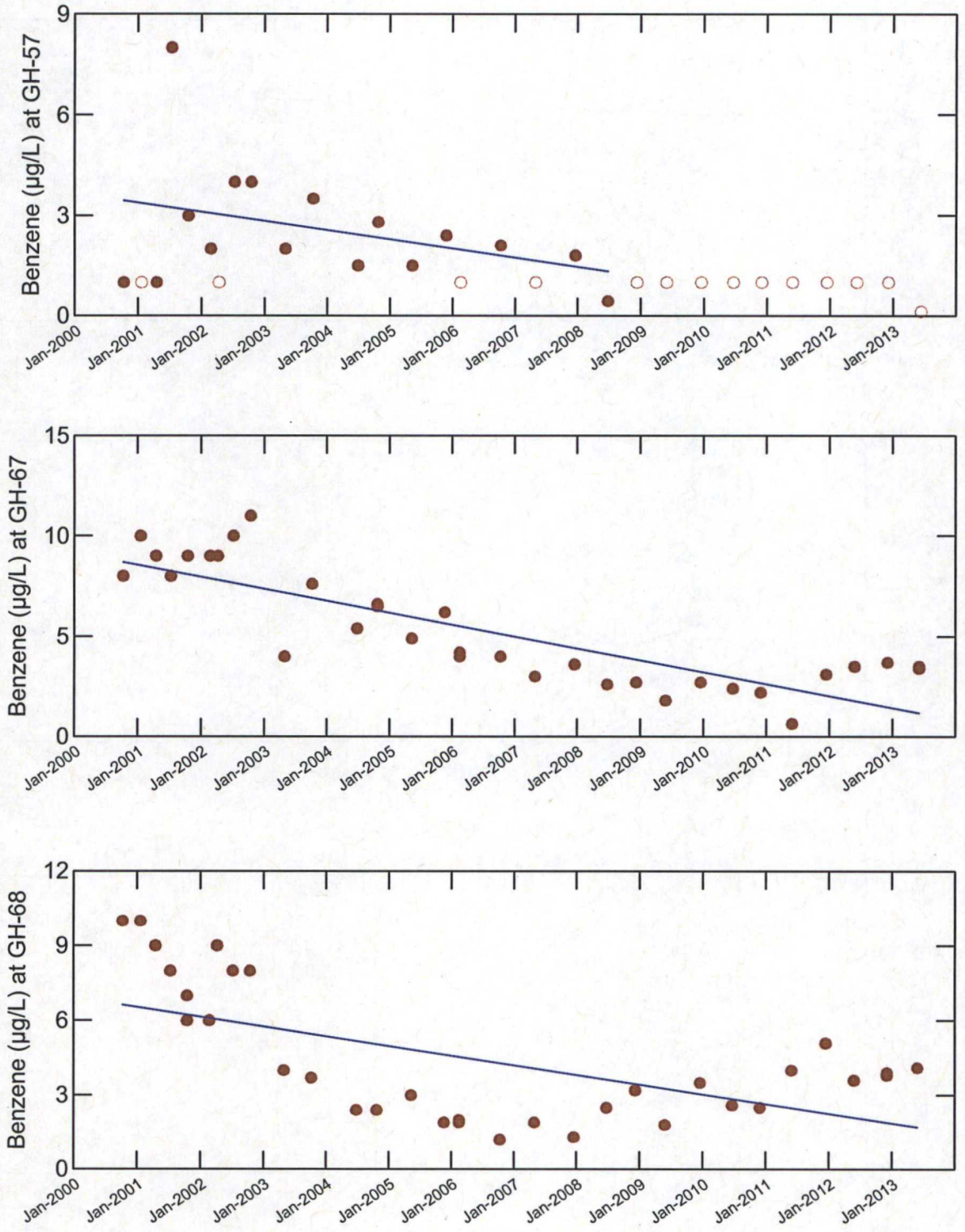
Notes:

- ● Detected result
- ○ Non-detect result
- —— Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 2
Benzene Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 17/2013



Notes:

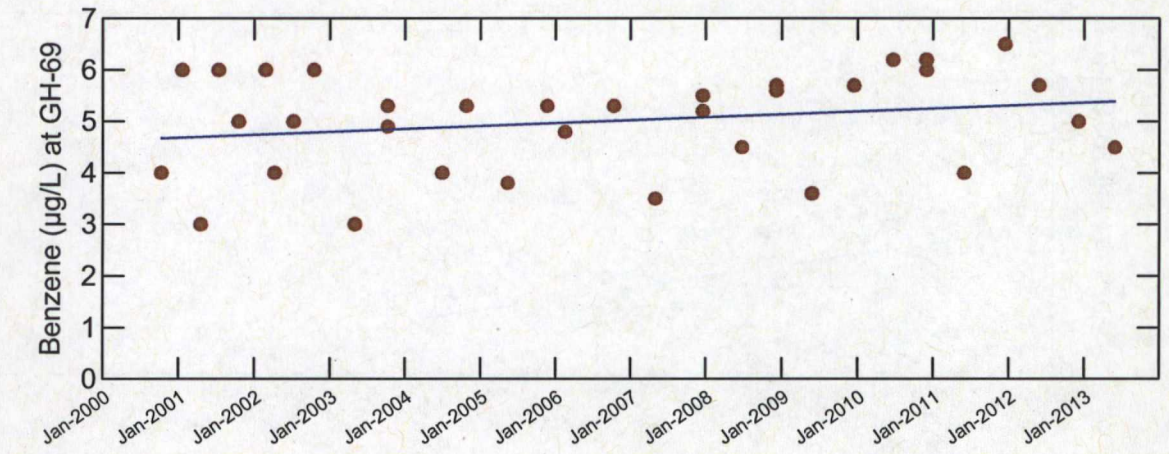
- Detected result
- Non-detect result

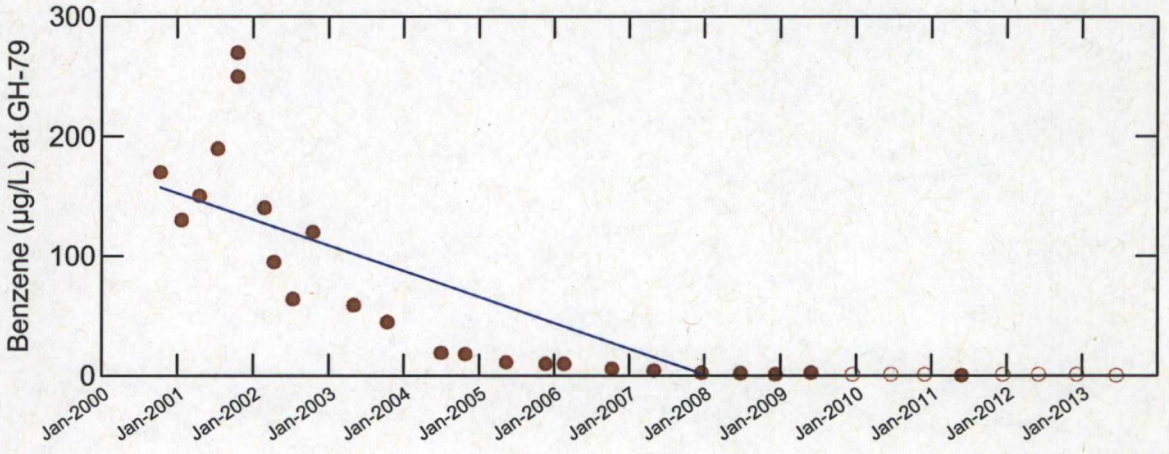
—— Line of Best Fit (linear regression)

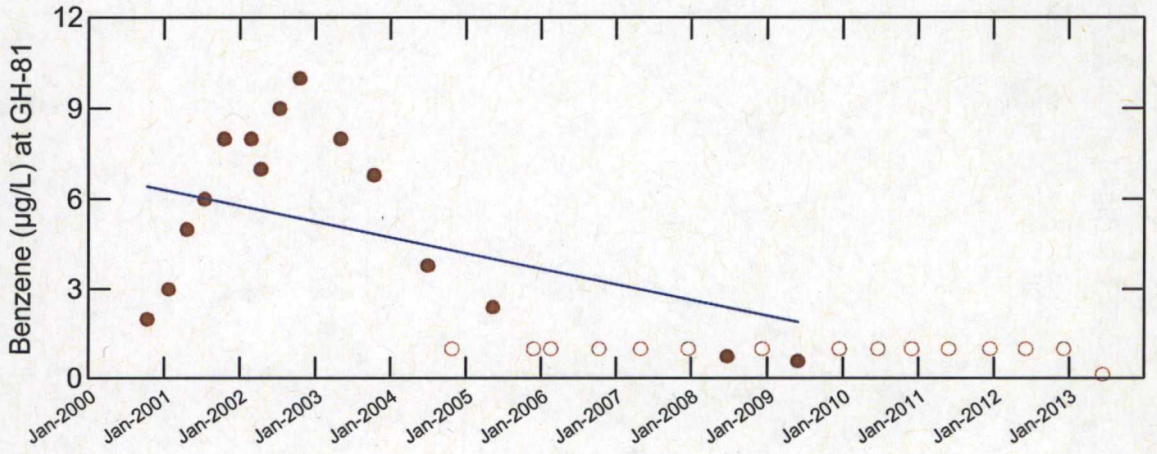
Line of Best Fit was calculated using detected values

figure 2
Benzene Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 17/2013







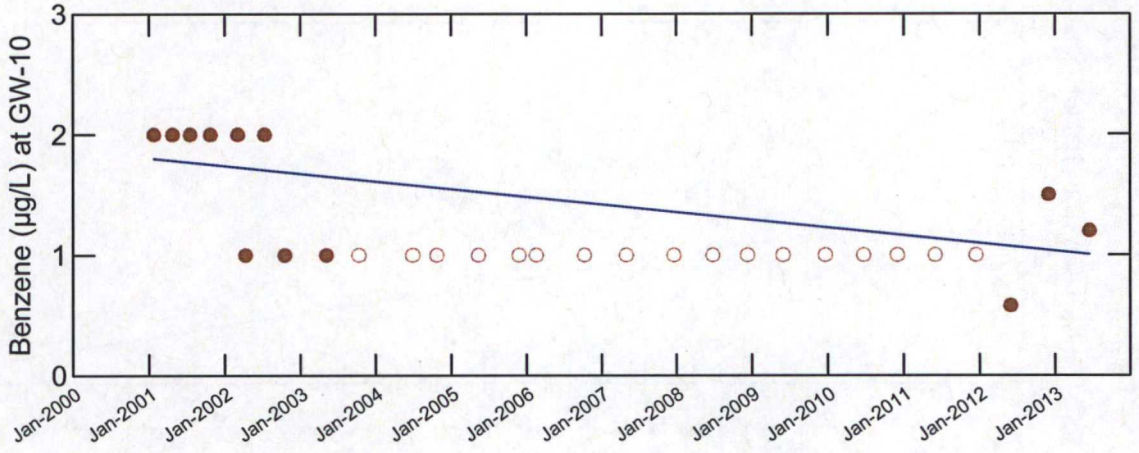
Notes:

- Detected result
- Non-detect result
- Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 2
Benzene Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 17/2013



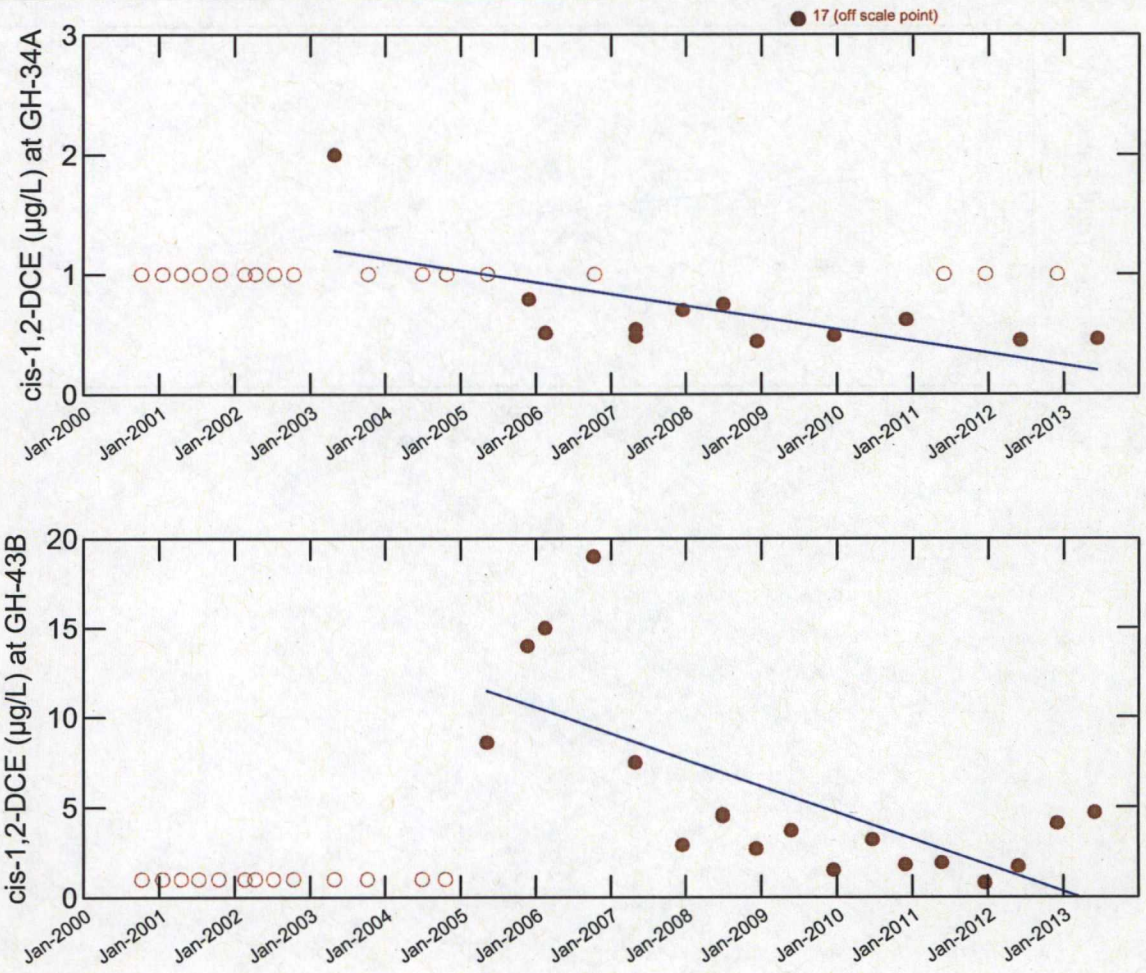
Notes:

- ● Detected result
- ○ Non-detect result
- —— Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 2
Benzene Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 17/2013



Notes:

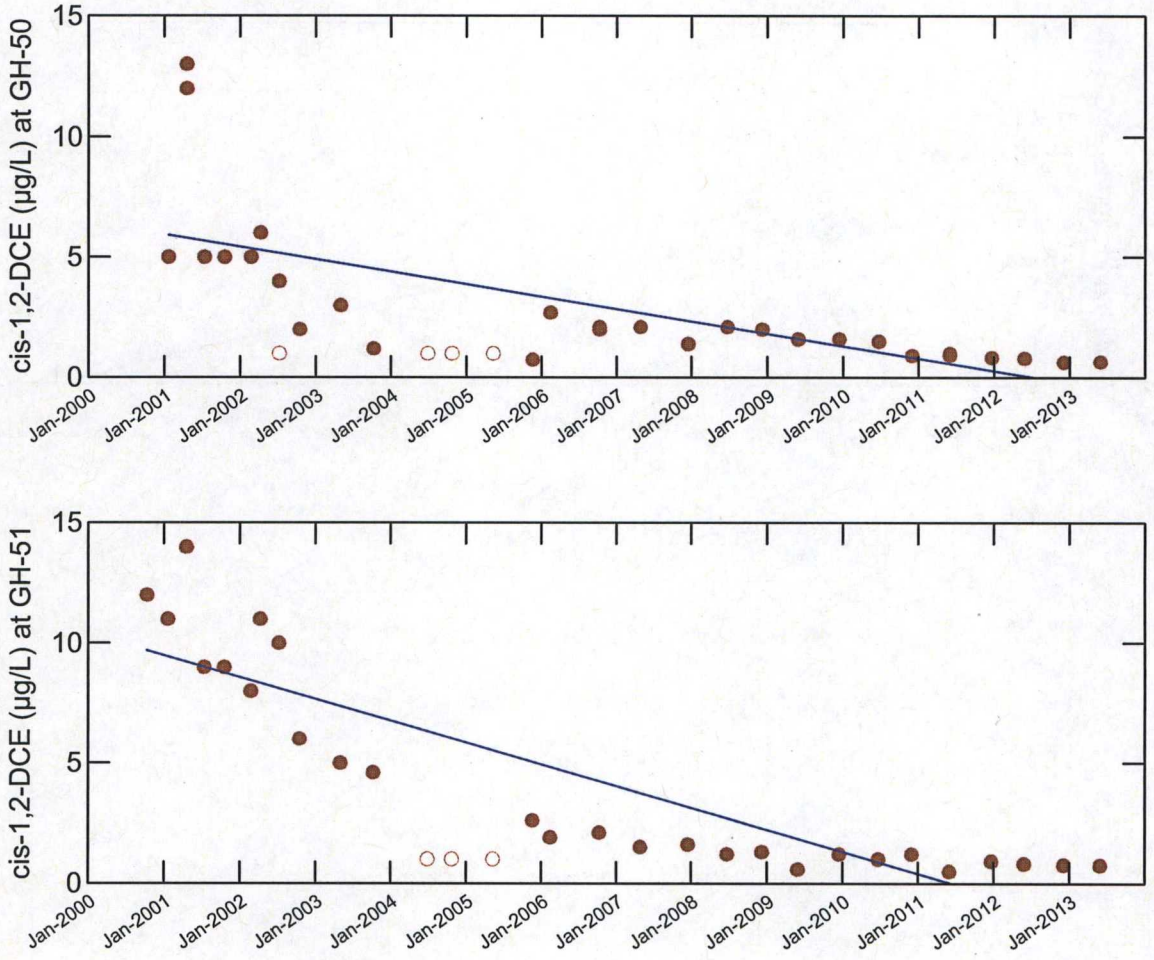
- Detected result
- Non-detect result

— Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 3
cis-1,2-DCE Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

051853-2013 (025) DECEMBER 17/2013

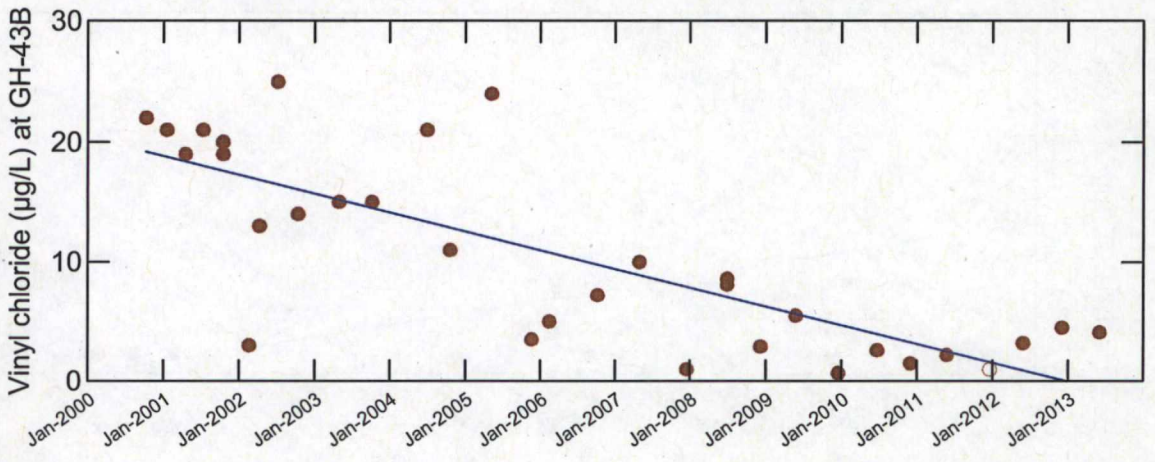


Notes:

- ● Detected result
- ○ Non-detect result
- —— Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 3
cis-1,2-DCE Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan



Notes:

● Detected result

○ Non-detect result

—— Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values

figure 4
Vinyl chloride Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

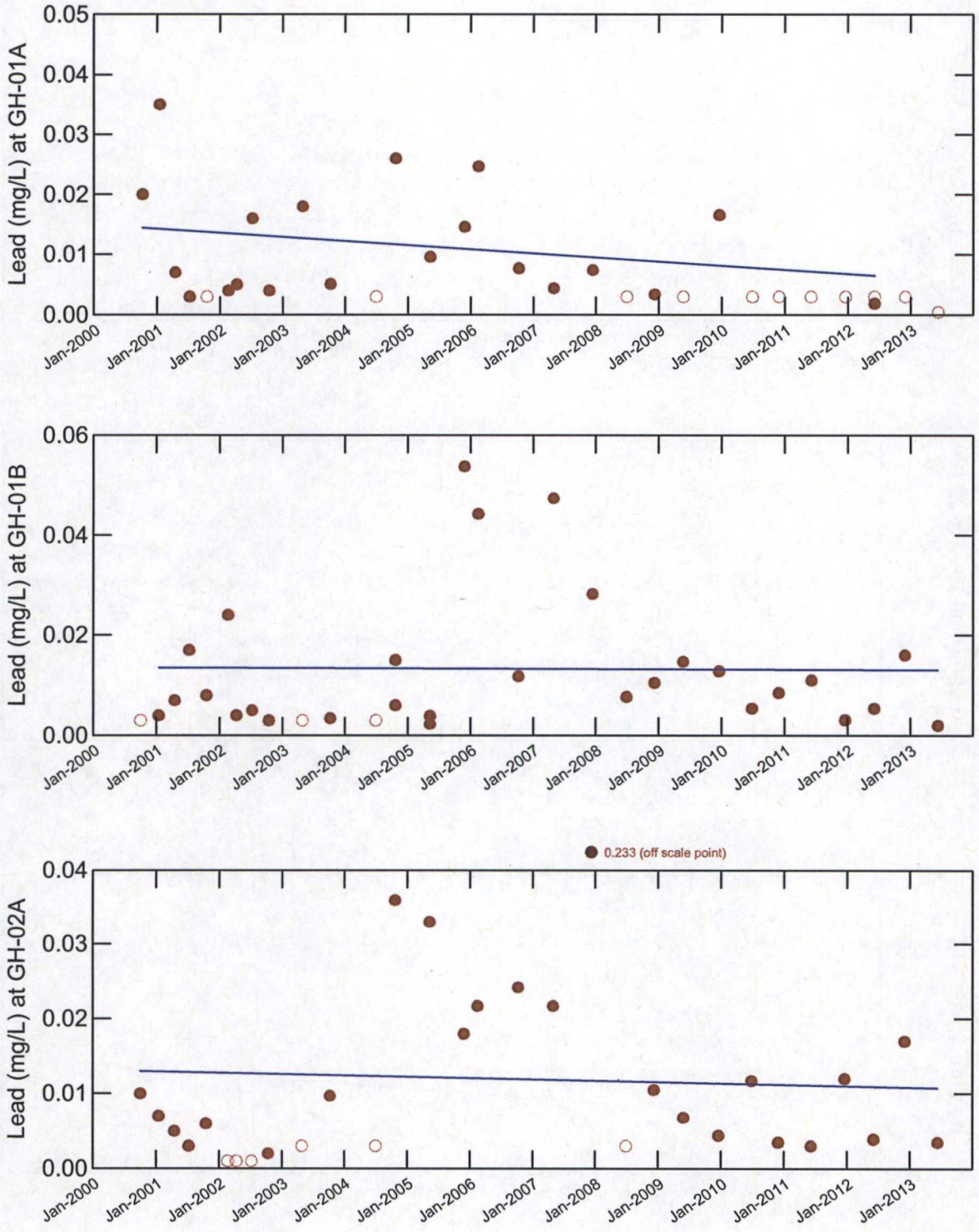
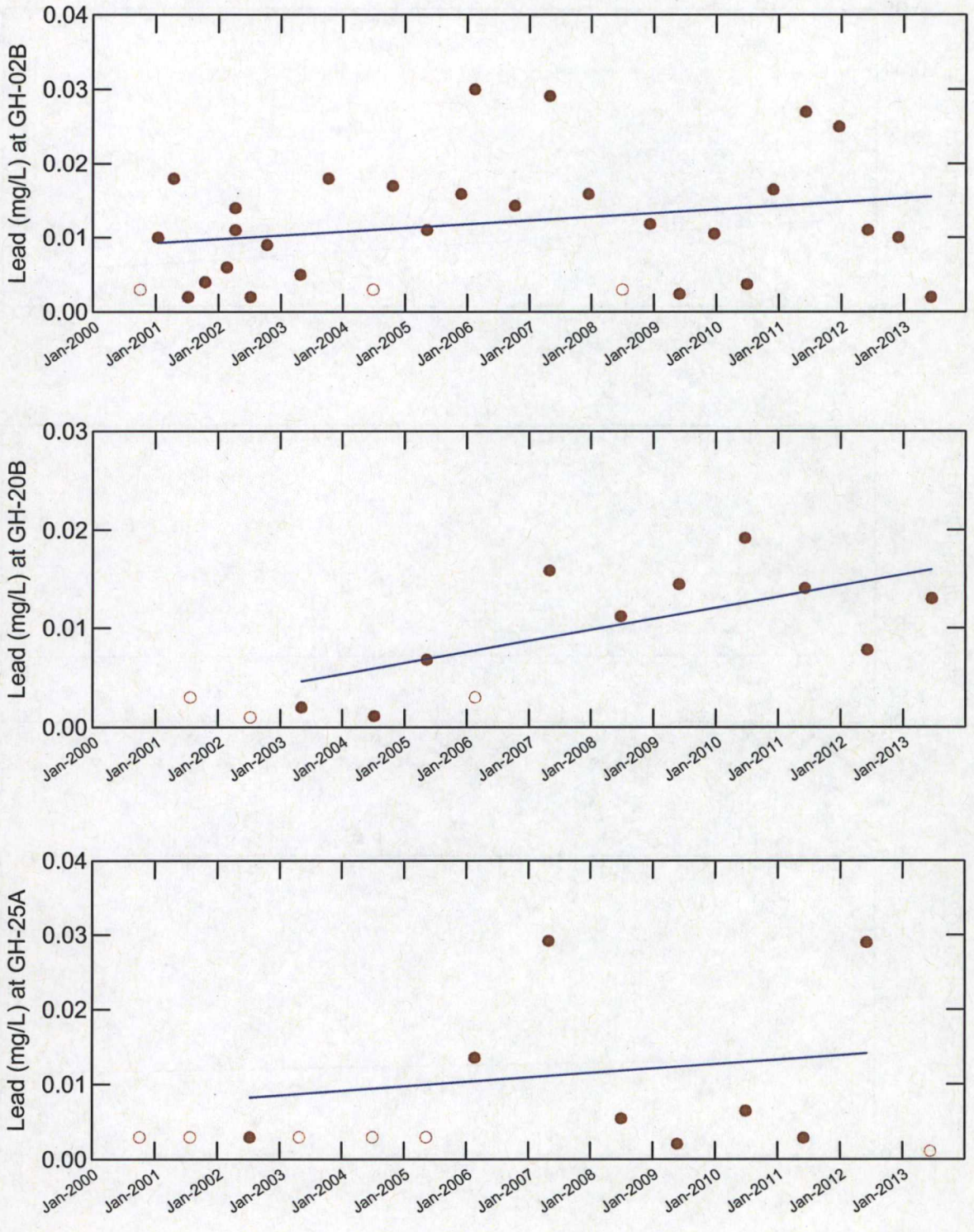


figure 5
Lead Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan



Notes:

- Detected result
- Non-detect result
- Line of Best Fit (linear regression)

Line of Best Fit was calculated using detected values.

figure 5
Lead Concentration vs. Time
G & H Landfill Site
Macomb County, Michigan

Tables

TABLE 1

TREND TEST RESULTS
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

		Mann-Kendall Trend test									
		Overall (2000 - 2013)					*Last 5 years (2009 - 2013)*				
Analyte	*Well*	*N*	*%ND*	*S*	*P*	*Conclusion*	*N*	*%ND*	*S*	*P*	*Conclusion*
Arsenic											
	GH-01A	30	7%	-38	0.509	No trend identified	9	0%	13	0.208	No trend identified
	GH-01B	29	83%	--	--	>50% ND	9	89%	--	--	>50% ND
	GH-02A	30	47%	129	0.016	**Increasing Trend**	9	33%	-5	0.670	No trend identified
	GH-02B	29	10%	141	0.009	**Increasing Trend**	9	0%	23	0.022	**Increasing Trend**
	GH-03A	29	0%	-20	0.722	No trend identified	9	0%	-16	0.118	No trend identified
	GH-03B	30	3%	-29	0.617	No trend identified	9	0%	-4	0.754	No trend identified
	GH-04A	19	0%	-29	0.327	No trend identified	9	0%	0	1.000	No trend identified
	GH-04B	28	32%	177	4.0E-04	**Increasing Trend**	9	0%	1	1.000	No trend identified
	GH-05A	11	100%	--	--	100% ND	0	--	--	--	Insufficient data
	GH-06A	30	37%	201	2.4E-04	**Increasing Trend**	9	11%	2	0.917	No trend identified
	GH-06B	29	14%	-220	3.9E-05	**Decreasing Trend**	9	33%	1	1.000	No trend identified
	GH-07A	30	13%	107	0.058	No trend identified	9	0%	-10	0.348	No trend identified
	GH-08A	21	81%	--	--	>50% ND	1	100%	--	--	Insufficient data
	GH-08B	30	90%	--	--	>50% ND	9	89%	--	--	>50% ND
	GH-09A	30	3%	-52	0.363	No trend identified	9	0%	0	1.000	No trend identified
	GH-09B	30	0%	198	4.4E-04	**Increasing Trend**	9	0%	-7	0.529	No trend identified
	GH-14A	13	100%	--	--	100% ND	5	100%	--	--	100% ND
	GH-14B	13	100%	--	--	100% ND	5	100%	--	--	100% ND
	GH-15A	13	31%	32	0.055	No trend identified	5	20%	0	1.000	No trend identified
	GH-15B	13	23%	41	0.014	**Increasing Trend**	5	0%	2	0.806	No trend identified
	GH-16A	13	31%	61	1.9E-04	**Increasing Trend**	5	0%	10	0.027	**Increasing Trend**
	GH-16B	7	86%	--	--	>50% ND	0	--	--	--	Insufficient data
	GH-17A	13	92%	--	--	>50% ND	5	80%	--	--	>50% ND
	GH-17B	13	38%	26	0.115	No trend identified	5	0%	0	1.000	No trend identified
	GH-19A	13	100%	--	--	100% ND	5	100%	--	--	100% ND
	GH-19B	13	100%	--	--	100% ND	5	100%	--	--	100% ND
	GH-20A	13	92%	--	--	>50% ND	5	100%	--	--	100% ND
	GH-20B	13	31%	42	0.011	**Increasing Trend**	5	0%	-2	0.806	No trend identified
	GH-22A	30	67%	--	--	>50% ND	9	56%	--	--	>50% ND
	GH-25A	14	7%	-17	0.380	No trend identified	5	0%	-5	0.312	No trend identified

TABLE 1

TREND TEST RESULTS
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

		Mann-Kendall Trend test									
		Overall (2000 - 2013)					*Last 5 years (2009 - 2013)*				
Analyte	*Well*	*N*	*%ND*	*S*	*P*	*Conclusion*	*N*	*%ND*	*S*	*P*	*Conclusion*
Arsenic (cont.)											
	GH-26A	13	31%	24	0.154	No trend identified	5	20%	-2	0.806	No trend identified
	GH-29A	13	62%	--	--	>50% ND	5	80%	--	--	>50% ND
	GH-29B	13	92%	--	--	>50% ND	5	100%	--	--	100% ND
	GH-33A	6	0%	1	1.000	No trend identified	1	0%	--	--	Insufficient data
	GH-33B	13	8%	11	0.541	No trend identified	5	0%	-2	0.806	No trend identified
	GH-34A	29	3%	-135	0.012	**Decreasing Trend**	8	0%	1	1.000	No trend identified
	GH-34B	30	27%	200	3.3E-04	**Increasing Trend**	9	0%	20	0.048	**Increasing Trend**
	GH-36A	13	77%	--	--	>50% ND	5	60%	--	--	>50% ND
	GH-36B	13	38%	31	0.058	No trend identified	5	0%	-1	1.000	No trend identified
	GH-43A	29	86%	--	--	>50% ND	9	89%	--	--	>50% ND
	GH-43B	29	31%	60	0.261	No trend identified	9	11%	8	0.466	No trend identified
	GH-44A	28	0%	-137	0.007	**Decreasing Trend**	9	0%	-4	0.754	No trend identified
	GH-45A	30	27%	152	0.006	**Increasing Trend**	9	0%	4	0.754	No trend identified
	GH-47A	13	92%	--	--	>50% ND	5	80%	--	--	>50% ND
	GH-47B	13	38%	30	0.068	No trend identified	5	20%	-2	0.806	No trend identified
	GH-50	29	0%	131	0.015	**Increasing Trend**	9	0%	-29	0.003	**Decreasing Trend**
	GH-50A	30	23%	144	0.010	**Increasing Trend**	9	0%	-4	0.754	No trend identified
	GH-50B	30	33%	61	0.275	No trend identified	9	11%	2	0.917	No trend identified
	GH-51	30	0%	98	0.083	No trend identified	9	0%	-7	0.529	No trend identified
	GH-53	30	0%	-190	0.001	**Decreasing Trend**	9	0%	5	0.675	No trend identified
	GH-55	30	0%	-217	1.2E-04	**Decreasing Trend**	9	0%	-4	0.754	No trend identified
	GH-57	30	0%	-148	0.009	**Decreasing Trend**	9	0%	-10	0.343	No trend identified
	GH-59	28	7%	-137	0.007	**Decreasing Trend**	9	0%	-22	0.029	**Decreasing Trend**
	GH-66	30	0%	-238	2.3E-05	**Decreasing Trend**	9	0%	16	0.118	No trend identified
	GH-67	30	0%	-247	1.1E-05	**Decreasing Trend**	9	0%	-7	0.529	No trend identified
	GH-68	30	0%	-216	1.2E-04	**Decreasing Trend**	9	0%	-11	0.295	No trend identified
	GH-69	30	0%	-225	6.4E-05	**Decreasing Trend**	9	0%	-13	0.208	No trend identified

TABLE 1

TREND TEST RESULTS
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

		Mann-Kendall Trend test									
		Overall (2000 - 2013)					*Last 5 years (2009 - 2013)*				
Analyte	*Well*	*N*	*%ND*	*S*	*P*	*Conclusion*	*N*	*%ND*	*S*	*P*	*Conclusion*
Arsenic (cont.)											
	GH-78	5	40%	5	0.312	No trend identified	0	--	--	--	Insufficient data
	GH-79	30	0%	-99	0.080	No trend identified	9	0%	8	0.466	No trend identified
	GH-81	29	10%	-182	0.001	**Decreasing Trend**	9	11%	0	1.000	No trend identified
	GH-83	31	0%	-246	3.1E-05	**Decreasing Trend**	9	0%	12	0.251	No trend identified
	GW-01	29	17%	-22	0.693	No trend identified	9	0%	2	0.917	No trend identified
	GW-08	27	96%	--	--	>50% ND	8	100%	--	--	100% ND
	GW-10	29	24%	22	0.691	No trend identified	9	11%	18	0.073	No trend identified
	GW-11	29	34%	132	0.012	**Increasing Trend**	9	11%	-4	0.754	No trend identified
Benzene											
	GH-50	29	7%	153	0.004	**Increasing Trend**	9	0%	-9	0.396	No trend identified
	GH-51	30	3%	152	0.007	**Increasing Trend**	9	0%	3	0.831	No trend identified
	GH-53	30	30%	-58	0.302	No trend identified	9	11%	14	0.175	No trend identified
	GH-57	30	47%	-186	4.8E-04	**Decreasing Trend**	9	100%	--	--	100% ND
	GH-66	30	0%	-299	1.0E-07	**Decreasing Trend**	9	0%	23	0.022	**Increasing Trend**
	GH-67	30	0%	-277	8.1E-07	**Decreasing Trend**	9	0%	18	0.076	No trend identified
	GH-68	30	0%	-148	0.009	**Decreasing Trend**	9	0%	20	0.048	**Increasing Trend**
	GH-69	30	0%	58	0.307	No trend identified	9	0%	-1	1.000	No trend identified
	GH-79	30	23%	-378	1.3E-11	**Decreasing Trend**	9	78%	--	--	>50% ND
	GH-81	30	50%	-209	6.9E-05	**Decreasing Trend**	9	89%	--	--	>50% ND
	GW-10	29	59%	--	--	>50% ND	9	67%	--	--	>50% ND

TABLE 1

TREND TEST RESULTS
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

		Mann-Kendall Trend test									
		Overall (2000 - 2013)					*Last 5 years (2009 - 2013)*				
Analyte	*Well*	*N*	*%ND*	*S*	*P*	*Conclusion*	*N*	*%ND*	*S*	*P*	*Conclusion*
cis-1,2-Dichloroethene											
	GH-34A	29	59%	--	--	>50% ND	8	38%	-11	0.203	No trend identified
	GH-43B	30	43%	159	0.003	**Increasing Trend**	9	0%	6	0.602	No trend identified
	GH-50	29	10%	-216	5.3E-05	**Decreasing Trend**	9	0%	-31	0.002	**Decreasing Trend**
	GH-51	30	10%	-285	3.9E-07	**Decreasing Trend**	9	0%	-11	0.297	No trend identified
Lead											
	GH-01A	30	33%	-155	0.005	**Decreasing Trend**	9	78%	--	--	>50% ND
	GH-01B	30	10%	44	0.442	No trend identified	9	0%	-13	0.208	No trend identified
	GH-02A	30	20%	41	0.473	No trend identified	9	0%	-1	1.000	No trend identified
	GH-02B	30	10%	59	0.300	No trend identified	9	0%	0	1.000	No trend identified
	GH-20B	13	23%	39	0.020	**Increasing Trend**	5	0%	-6	0.221	No trend identified
	GH-25A	14	43%	26	0.153	No trend identified	5	20%	0	1.000	No trend identified
Vinyl chloride											
	GH-43B	30	3%	-243	1.6E-05	**Decreasing Trend**	9	11%	6	0.602	No trend identified

Notes:

N: number of samples.
%ND: percent non-detects.
S: Mann-Kendall test statistic (sum of the signs of all possible pair-wise data comparisons).
P: Probability of significance. For 95 percent confidence, a P-value equal to or below 0.05 is required.
>50% ND - Over 50 percent non-detects.
100% ND - No detected results.

Appendices

Appendix A

Calculation of Background Value for Arsenic in Groundwater

CONESTOGA-ROVERS & ASSOCIATES

651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2
Telephone: (519) 884-0510 Fax: (519) 884-0525
www.CRAworld.com

MEMORANDUM

TO:	Gavin O'Neil Tracy Beadow	REF. NO.:	051853
FROM:	Daniela Araujo	DATE:	December 18, 2013
RE:	**Calculation of Background Value for Arsenic in Groundwater G&H Landfill Site Macomb County, Michigan**		

1.0 Introduction

Conestoga-Rovers & Associates (CRA) has undertaken a statistical evaluation of concentrations of arsenic found in groundwater samples collected from background locations upgradient from the G&H Landfill in Macomb County, Michigan (Site). The goal of this evaluation has been to establish a Facility-Specific Background Threshold Value (BTV) for naturally-occurring arsenic in local groundwater. This BTV has been calculated using analytical data from groundwater samples collected from representative upgradient (background) wells near the Site, as described in Section 3 of this memorandum.

The calculation of background values is discussed in the Michigan Department of Environmental Quality (MDEQ) document *Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria* (Michigan, 2002, referred to as the "S^{3}TM"). However, MDEQ recommends consideration of the statistical methods implemented in U.S.EPA's ProUCL software, which more appropriately deal with non-detects in data sets during the computation of BTVs. Based on these recommendations, a Facility-Specific BTV has been generated following the methods laid out in the ProUCL Technical Guide (USEPA, 2013) and using the current version (5.0.00) of the ProUCL software package.

2.0 Statistical Methods

Guidance for collecting and analyzing groundwater background samples in order to calculate Facility-Specific Background Concentrations for assessing compliance with Part 201 requirements is detailed in Chapter 4 of "Statistical Methods" (Tab 7, Section 4.3) of the S^{3}TM. This guidance is also referred to in "Statistical Guidesheets 10, 1, 2 and 6" of the S^{3}TM. Facility-Specific Background Concentrations are suitable for background comparisons performed on a point-by-point basis. However, as noted above in the introduction, more current statistical methods are recommended and implemented in USEPA's ProUCL software. Nonetheless, the requirements of the Michigan Part 201 guidance need to be considered in the BTV calculation.

The general approach of USEPA (2013) in determining BTVs is to estimate an upper bound on the background population using a method appropriate for the observed data distribution (i.e., normal, gamma-distributed, lognormal or none of these). Statistical limits such as upper tolerance limits (UTLs) or upper prediction limit (UPLs) may be used. Such values take into consideration sampling variability (both in background sampling and in on-site sampling), and provide BTVs which are expected to rarely be exceeded in samples collected from groundwater

consistent with background conditions (e.g., no more frequently than 1 in 100 samples, if a 99 percent value is selected).

Since the original methodology presented in the S^{3}TM produces a background value above approximately the 99th percentile of background[1], a confidence level of 99 percent has been selected for use in the BTV calculations. Thus, for the purposes of calculating Facility-Specific BTVs, upper prediction limits (UPLs) on the next future sample, with 99 percent confidence, are the selected BTVs.

Statistical calculations were computed using USEPA's statistical software ProUCL (version 5.0.00). Chapter 5 of USEPA (2013) describes statistical methodologies for calculating BTVs. The selection of an appropriate method varies by characteristics of individual data, in particular (i) the observed data distribution, (ii) the percentage of non-detect values present, and (iii) the presence of statistical outliers.

For further discussion of specific BTV calculation methodologies, please refer to Chapter 5 of the USEPA (2013).

A number of assumptions for background data set must be statistically assessed before the BTV calculations are performed. The following memorandum sections provide the required details for the statistical calculations.

2.1 Data Distribution Testing

The selection of appropriate background value calculation methods varies with the characteristics of each data set (Michigan, 2002; USEPA, 2013). In selecting a BTV method, one must assess: (i) the observed data distribution, (ii) the percentage of non-detect values present, and (iii) the presence of statistical outliers. Methods for assessing these characteristics are provided in ProUCL.

ProUCL assesses each data set for the following distribution patterns (in priority order): normal, gamma-distributed, then lognormal. If a data set is found to be described by one of these distributions, then a BTV calculation method for the observed data distribution is used. If, however, a particular data set does not follow one of these distributions, it is identified as not having an identifiable distribution and non-parametric (rank-based) statistical methods are used for subsequent calculations.

2.2 Non-Detects in the Background Data Set

The calculation of BTVs when non-detect data are present is considered in Chapter 5 of USEPA (2013). In particular, the Kaplan-Meier (KM) method for estimation of sample means and standard deviations when single or multiple detection limits are present is recommended (USEPA, 2013; Helsel, 2005). The KM method is described in Section 5.3 of USEPA (2013).

2.3 Outlier Testing

Once a data distribution has been established for a data set, an assessment of statistical outliers (extreme low or high values appearing atypical of the remaining data) is carried out considering the observed data distribution. In the current evaluation, any suspected statistical outliers were tested using Rosner's test (for greater than 25 observations). Details of these methods are found in Section 7.3.2 of USEPA (2013).

---

[1] The S^{3}TM method uses the mean + 3 standard deviations for the background value. If a data set is normally distributed, this corresponds to the 99.87th percentile.

3.0 Scope of Data

Samples suitable for generating a Facility-Specific Background Concentration of arsenic in groundwater were collected in 16 background wells between 2001 and 2013. A total of 171 background samples are available for calculations.

The background data utilized for the generation of BTVs are provided in Table 1. The S^{3}TM recommends a minimum of nine background samples for establishing a Facility-Specific BTVs ("Statistical Guidesheet 10" in Michigan, 2002). The number of background samples collected therefore exceeds the requirements of the guidance.

4.0 Results

As noted previously, a BTV was calculated for arsenic using the methods available in ProUCL. Specifically, a 99 percent UPL on the next future sample were utilized as the BTV, considering the observed data distribution and percentage of non-detect data present. The choice of 99 percent confidence value was consistent with the methodology presented in the S^{3}TM (mean + 3 standard deviations), which is equivalent to a 99.87th percentile value of a normal distribution.

ProUCL tests data distributions and the presence of non-detects in calculating BTVs. Based on the characteristics of the data set, arsenic detected concentrations were found to be lognormally distributed. No outliers were found by Rosner's test using log-transformed data (according to data distribution). Therefore, for the background arsenic data set considered in the present evaluation, the 99% KM UPL (lognormal) method was selected. This method consists on a 99 percent Student's-t upper prediction limit using the Kaplan-Meier (KM) method to accommodate non-detect results, used when non-detects are present and/or non-normal data distributions are present (see Section 5.3.1.5 of USEPA, 2013).

The calculated arsenic BTV was 0.0253 mg/L. The ProUCL output is shown in Table 2.

5.0 Conclusions

The calculated arsenic BTV of 0.025 mg/L is appropriate for point-by-point comparisons of on-Site data. Where on-Site concentrations of arsenic are above the Background Value, follow-up assessment may be necessary. In such cases, professional judgment is to be used to determine whether or not this is a *marginal* exceedance of the Background Value (per the footnote on page 7.85 of the S^{3}TM).

6.0 References

Helsel, D. R. 2005. Nondetects and Data Analysis. Statistics for Censored Environmental Data. John Wiley and Sons, N.Y.

Michigan, 2002. Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria. Michigan Department of Environmental Quality, Environmental Response Division.

USEPA, 2013. ProUCL Version 5.0.00 Technical Guide. United States Environmental Protection Agency, Office of Research and Development, Washington DC. EPA/600/R-07/041.

TABLE 1

PROUCL OUTPUT
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

WELL	DATE	ARSENIC (mg/L)	WELL	DATE	ARSENIC (mg/L)
GH-14A	7/20/2001	0.02 U	GH-15B	7/6/2004	0.0051 J
GH-14A	7/10/2002	0.02 U	GH-15B	5/12/2005	0.0037 J
GH-14A	5/6/2003	0.02 U	GH-15B	2/22/2006	0.016 J
GH-14A	7/6/2004	0.020 U	GH-15B	5/3/2007	0.005 J
GH-14A	5/12/2005	0.020 U	GH-15B	6/24/2008	0.0163 J
GH-14A	2/22/2006	0.02 U	GH-15B	6/1/2009	0.0038 J
GH-14A	5/4/2007	0.02 U	GH-15B	6/25/2010	0.0147 J
GH-14A	6/24/2008	0.02 U/0.02 U	GH-15B	6/8/2011	0.012 J
GH-14A	6/1/2009	0.02 U	GH-15B	5/31/2012	0.03 /0.011 J
GH-14A	6/25/2010	0.02 U	GH-16A	7/20/2001	0.02 U
GH-14A	6/8/2011	0.02 U	GH-16A	7/10/2002	0.02 U
GH-14A	5/30/2012	0.02 U	GH-16A	5/6/2003	0.02 U
GH-14A	6/21/2013	0.02 U	GH-16A	7/6/2004	0.0036 J
GH-14B	7/20/2001	0.02 U	GH-16A	5/12/2005	0.0060 J
GH-14B	7/10/2002	0.02 U	GH-16A	2/24/2006	0.0084 J/0.0092 J
GH-14B	5/6/2003	0.02 U/0.02 U	GH-16A	5/4/2007	0.02 U
GH-14B	7/6/2004	0.020 U	GH-16A	6/24/2008	0.009 J
GH-14B	5/12/2005	0.020 U	GH-16A	6/1/2009	0.006 J
GH-14B	2/22/2006	0.02 U	GH-16A	6/25/2010	0.0094 J
GH-14B	5/4/2007	0.02 U/0.02 U	GH-16A	6/8/2011	0.011 J
GH-14B	6/24/2008	0.02 U	GH-16A	5/30/2012	0.013 J
GH-14B	6/1/2009	0.02 U	GH-16A	6/20/2013	0.015 J
GH-14B	6/25/2010	0.02 U	GH-16B	7/20/2001	0.02 U
GH-14B	6/8/2011	0.02 U	GH-16B	7/10/2002	0.02 U
GH-14B	5/30/2012	0.02 U	GH-16B	5/6/2003	0.02 U
GH-14B	6/21/2013	0.02 U	GH-16B	7/6/2004	0.020 U
GH-15A	7/21/2001	0.02 U	GH-16B	5/12/2005	0.020 U
GH-15A	7/11/2002	0.02 U	GH-16B	2/24/2006	0.02 U
GH-15A	5/6/2003	0.02 U	GH-16B	5/4/2007	0.0124 J
GH-15A	7/6/2004	0.0038 J	GH-17A	7/26/2001	0.02 U/0.02 U
GH-15A	5/12/2005	0.0049 J	GH-17A	7/11/2002	0.02 U
GH-15A	2/22/2006	0.007 J	GH-17A	5/7/2003	0.02 U/0.02 U
GH-15A	5/3/2007	0.0097 J	GH-17A	7/7/2004	0.020 U
GH-15A	6/24/2008	0.0051 J	GH-17A	5/12/2005	0.020 U
GH-15A	6/1/2009	0.0055 J	GH-17A	2/22/2006	0.02 U
GH-15A	6/25/2010	0.0103 J	GH-17A	5/4/2007	0.02 U
GH-15A	6/8/2011	0.02 U	GH-17A	6/25/2008	0.02 U
GH-15A	5/31/2012	0.0047 J	GH-17A	6/2/2009	0.02 U
GH-15A	5/31/2012	0.0039 J/0.0069 J	GH-17A	6/28/2010	0.02 U
GH-15B	7/21/2001	0.02 U	GH-17A	5/31/2011	0.031
GH-15B	7/11/2002	0.02 U	GH-17A	5/30/2012	0.02 U
GH-15B	5/6/2003	0.02 U	GH-17A	6/18/2013	0.02 U
GH-17B	7/26/2001	0.02 U	BW-01A	6/8/2011	0.02 U/0.02 U
GH-17B	7/11/2002	0.02 U	BW-01A	5/31/2012	0.02 U
GH-17B	5/7/2003	0.02 U	BW-01B	7/6/2004	0.020 U
GH-17B	7/7/2004	0.020 U	BW-01B	5/13/2005	0.020 U
GH-17B	5/12/2005	0.010 J	BW-01B	2/21/2006	0.02 U
GH-17B	2/22/2006	0.0112 J	BW-01B	5/4/2007	0.02 U/0.02 U

Data Not Gamma Distributed at 5% Significance Level

TABLE 1

PROUCL OUTPUT
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

WELL	DATE	ARSENIC (mg/L)	WELL	DATE	ARSENIC (mg/L)
		Gamma Statistics on Detected Data Only			
GH-17B	6/28/2010	0.0086 J	BW-01B	5/31/2012	0.02 U
GH-17B	5/31/2011	0.0047 J	BW-02A	7/6/2004	0.020 U
GH-17B	5/30/2012	0.011 J	BW-02A	5/19/2005	0.0017 J
GH-17B	6/18/2013	0.0048 J	BW-02A	2/21/2006	0.02 U/0.02 U
GH-47A	7/21/2001	0.02 U/0.02 U	BW-02A	5/4/2007	0.02 U
GH-47A	7/11/2002	0.02 U	BW-02A	5/26/2009	0.02 U
GH-47A	5/8/2003	0.02 U	BW-02A	6/25/2010	0.02 U
GH-47A	7/7/2004	0.020 U	BW-02A	6/7/2011	0.0074 J/0.007 J
GH-47A	5/12/2005	0.020 U	BW-02A	5/31/2012	0.02 U
GH-47A	2/23/2006	0.02 U	BW-02B	7/6/2004	0.0023 J
GH-47A	5/3/2007	0.02 U	BW-02B	5/19/2005	0.0042 J/0.0041 J
GH-47A	6/24/2008	0.02 U	BW-02B	2/21/2006	0.0058 J
GH-47A	5/27/2009	0.016 J	BW-02B	5/4/2007	0.0079 J
GH-47A	6/28/2010	0.02 U	BW-02B	5/27/2009	0.0073 J
GH-47A	5/31/2011	0.02 U	BW-02B	6/25/2010	0.0055 J/0.0051 J
GH-47A	5/30/2012	0.02 U	BW-02B	6/7/2011	0.02 U
GH-47A	6/19/2013	0.02 U/0.02 U	BW-02B	5/31/2012	0.043
GH-47B	7/21/2001	0.02 U	BW-03A	7/6/2004	0.020 U
GH-47B	7/11/2002	0.02 U/0.02 U	BW-03A	5/19/2005	0.020 U
GH-47B	5/8/2003	0.02 U	BW-03A	2/22/2006	0.02 U
GH-47B	7/8/2004	0.0030 J/0.0028 J	BW-03A	5/4/2007	0.02 U
GH-47B	5/12/2005	0.0044 J	BW-03A	5/27/2009	0.02 U
GH-47B	2/23/2006	0.02 U	BW-03A	6/25/2010	0.02 U
GH-47B	5/3/2007	0.0053 J	BW-03A	5/31/2011	0.02 U
GH-47B	6/24/2008	0.008 J	BW-03A	5/31/2012	0.02 U
GH-47B	5/27/2009	0.0073 J	BW-03B	7/6/2004	0.02 U/0.02 U
GH-47B	6/28/2010	0.0048 J/0.0034 J	BW-03B	5/19/2005	0.020 U
GH-47B	5/31/2011	0.0037 J	BW-03B	2/22/2006	0.02 U
GH-47B	5/30/2012	0.02 U	BW-03B	5/4/2007	0.02 U/0.02 U
GH-47B	6/19/2013	0.0082 J	BW-03B	5/27/2009	0.02 U
BW-01A	7/6/2004	0.020 U	BW-03B	6/25/2010	0.02 U
BW-01A	5/13/2005	0.020 U	BW-03B	5/31/2011	0.02 U
BW-01A	2/21/2006	0.02 U	BW-03B	5/31/2012	0.02 U
BW-01A	5/4/2007	0.02 U			
BW-01A	5/26/2009	0.02 U			
BW-01A	6/25/2010	0.02 U			

TABLE 2

PROUCL OUTPUT
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

Background Statistics for Data Sets with Non-Detects

User Selected Options

Date/Time of Computation	12/18/2013 1:19:10 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	99%
Coverage	99%
Different or Future K Observations	1
Number of Bootstrap Operations	10000

Arsenic

General Statistics

Total Number of Observations	171	Number of Missing Observations	0
Number of Distinct Observations	47		
Number of Detects	55	Number of Non-Detects	116
Number of Distinct Detects	46	Number of Distinct Non-Detects	1
Minimum Detect	0.0017	Minimum Non-Detect	0.02
Maximum Detect	0.043	Maximum Non-Detect	0.02
Variance Detected	4.8682E-5	Percent Non-Detects	67.84%
Mean Detected	0.00894	SD Detected	0.00698
Mean of Detected Logged Data	-4.92	SD of Detected Logged Data	0.617

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.712	d2max (for USL)	3.775

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.734	**Normal GOF Test on Detected Observations Only**	
5% Shapiro Wilk P Value	1.154E-12	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.167	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.119	Data Not Normal at 5% Significance Level	

Data Not Normal at 5% Significance Level

Kaplan Meier (KM) Background Statistics Assuming Normal Distribution

Mean	0.00806	SD	0.00507
99% UTL99% Coverage	0.0218	99% KM UPL (t)	0.02
90% KM Percentile (z)	0.0146	95% KM Percentile (z)	0.0164
99% KM Percentile (z)	0.0198	99% KM USL	0.0272

DL/2 Substitution Background Statistics Assuming Normal Distribution

Mean	0.00966	SD	0.00396
99% UTL99% Coverage	0.0204	99% UPL (t)	0.019
90% Percentile (z)	0.0147	95% Percentile (z)	0.0162
99% Percentile (z)	0.0189	99% USL	0.0246

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.95	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.76	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.125	**Kolmogrov-Smirnoff GOF**	
5% K-S Critical Value	0.121	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

TABLE 2

PROUCL OUTPUT
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

Gamma Statistics on Detected Data Only

k hat (MLE)	2.612	k star (bias corrected MLE)	2.482
Theta hat (MLE)	0.00342	Theta star (bias corrected MLE)	0.0036
nu hat (MLE)	287.3	nu star (bias corrected)	273
MLE Mean (bias corrected)	0.00894		
MLE Sd (bias corrected)	0.00568	99% Percentile of Chisquare (2k)	15.02

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.0017	Mean	0.0105
Maximum	0.043	Median	0.01
SD	0.00462	CV	0.44
k hat (MLE)	6.023	k star (bias corrected MLE)	5.921
Theta hat (MLE)	0.00175	Theta star (bias corrected MLE)	0.00178
nu hat (MLE)	2060	nu star (bias corrected)	2025
MLE Mean (bias corrected)	0.0105	MLE Sd (bias corrected)	0.00432
99% Percentile of Chisquare (2k)	25.98	90% Percentile	0.0163
95% Percentile	0.0185	99% Percentile	0.0231

The following statistics are computed using Gamma ROS Statistics on Imputed Data

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
99% Approx. Gamma UTL with 99% Coverage	0.0258	0.0267	99% Approx. Gamma UPL	0.0231	0.0237
99% Gamma USL	0.035	0.0372			

The following statistics are computed using gamma distribution and KM estimates

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

k hat (KM)	2.532		nu hat (KM)	865.9	
	WH	HW		WH	HW
99% Approx. Gamma UTL with 99% Coverage	0.0249	0.0259	99% Approx. Gamma UPL	0.0217	0.0223
99% Gamma USL	0.0361	0.0389			

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.0972	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.119	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects

Mean in Original Scale	0.00814	Mean in Log Scale	-4.974
SD in Original Scale	0.00526	SD in Log Scale	0.567
99% UTL99% Coverage	0.0322	99% BCA UTL99% Coverage	0.043
99% Bootstrap (%) UTL99% Coverage	0.043	99% UPL (t)	0.0263
90% Percentile (z)	0.0143	95% Percentile (z)	0.0176
99% Percentile (z)	0.0259	99% USL	0.0588

TABLE 2

PROUCL OUTPUT
G&H LANDFILL
MACOMB COUNTY, MICHIGAN

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean of Logged Data	-4.976	99% KM UTL (Lognormal)99% Coverage	0.0307
KM SD of Logged Data	0.551	99% KM UPL (Lognormal)	0.0253
99% KM Percentile Lognormal (z)	0.0249	99% KM USL (Lognormal)	0.0552

Background DL/2 Statistics Assuming Lognormal Distribution

Mean in Original Scale	0.00966	Mean in Log Scale	-4.706
SD in Original Scale	0.00396	SD in Log Scale	0.378
99% UTL99% Coverage	0.0252	99% UPL (t)	0.022
90% Percentile (z)	0.0147	95% Percentile (z)	0.0168
99% Percentile (z)	0.0218	99% USL	0.0376

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

Nonparametric Distribution Free Background Statistics

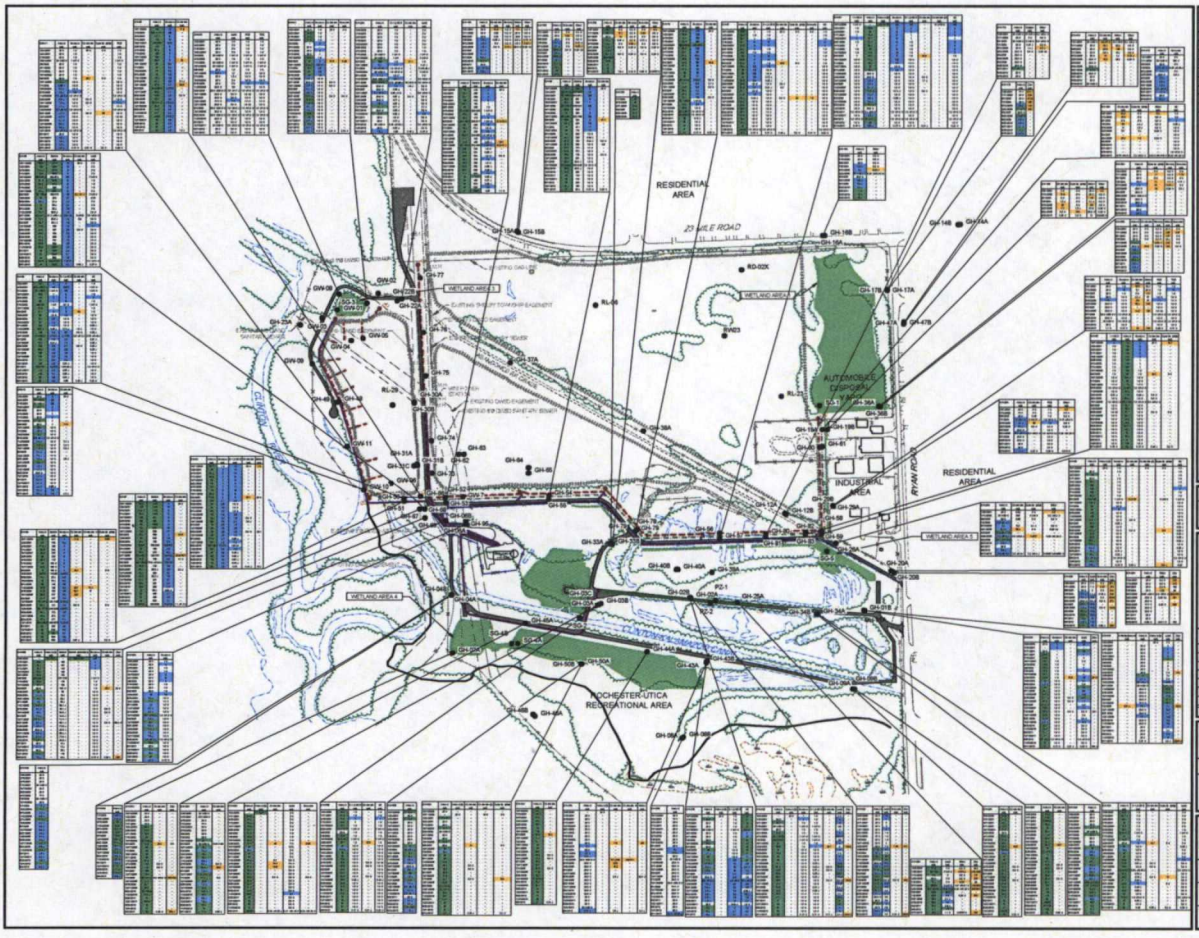
Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)

Order of Statistic, r	171	99% UTL with99% Coverage	0.043
Approximate f	1.727	Confidence Coefficient (CC) achieved by UTL	0.821
99% UPL	0.0344	99% USL	0.043
99% KM Chebyshev UPL	0.0586		

Note: The use of USL to estimate a BTV is recommended only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations. The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

Plans



No	Revision	Date	Initial

0 100 200ft

LEGEND

- LANDFILL BOUNDARY
- USEPA SITE FENCE/BOUNDARY
- DITCH, STREAM OR RIVER
- RAILROAD (GRADE UNMAINTAINED)
- GAS LINE
- DWSD SANITARY SEWER
- DWSD WATERMAIN
- INFERRED LIMIT OF UPPER AQUIFER
- LEACHATE COLLECTION SYSTEM
- GROUNDWATER EXTRACTION SYSTEM
- BARRIER WALL ALIGNMENT
- FORCEMAIN
- COLLECTION SUMP
- CLEANOUT
- WET WELL
- EXTRACTION WELL
- ACCESS ROAD
- MONITORING WELL
- GROUNDWATER ELEVATION (ft. AMSL)
- GSI EXCEEDANCES
- CONSENT DECREE EXCEEDANCES
- GSI EXCEEDANCES/CONSENT DECREE EXCEEDANCES

SOURCE: ADVANCED MAPPING TECHNOLOGIES AERIAL PHOTOGRAPHY DATE: FEB. 5, 1993

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

G&H LANDFILL
MACOMB COUNTY, MICHIGAN

ANALYTICAL DATABOX SUMMARY

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager	Reviewed By	Date
G.O	T.B	DECEMBER 2013

Scale	Project No.	Report No.	Drawing No.
1"=200'	051853-2013	025	PLAN 1

051853-001(025)GN-DEC01 DEC 24/2013